instruction manual

INSTRUCTION MANUAL

MODEL 7152 & 7153
LIMIT EPUT®

Beckman®

Berkeley Division

INSTRUCTION MANUAL

MODEL 7152 & 7153
LIMIT EPUT®

Serial No. _____

NOTE

If model number is followed by one or more letters, the instrument covered by this manual has been modified. See section on modifications.

Beckman/Berkeley Division
Richmond 3, California

March 1959

WARRANTY

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(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

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MODIFICATIONS (7000 Series)

DIAGRAMS

Model 7152, Logic Diagram, Dwg. No. 7152 C 4
Model 7153, Logic Diagram, Dwg. No. 7153 C 4
Gate, Control and Counting Circuits, Schematic Diagram, Dwg. No. 7152 D 2
Input Channel, Schematic Diagram, Dwg. No. 7000 C 300
Oscillator and Shaper, Schematic Diagram, Dwg. No. 7000 C 419
Divider Chain (100 kc to 1 cps), Schematic Diagram, Dwg. No. 7152 D 3
Single Limit Selector Circuit, Schematic Diagram, Dwg. No. 7152 D 1
Dual Limit Selector Circuit, Schematic Diagram, Dwg. No. 7153 D 1
Power Supply, Schematic Diagram, Dwg. No. 7370 C 100

APPENDICES

Instruction Manual, Model 705AH DCU

Instruction Manual, Model 705AHP DCU

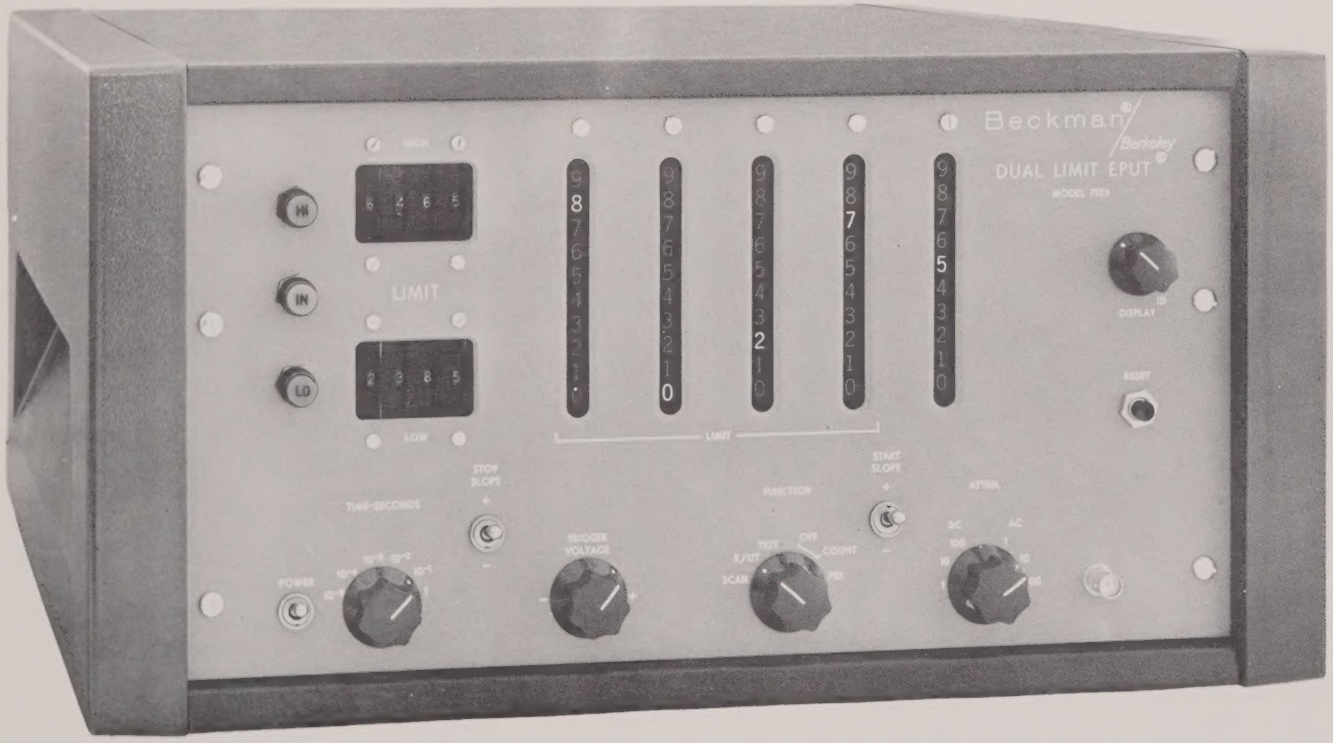

FIG. 1. Front panel of the Model 7153. The Model 7152 is similar but has only one set of limit selectors and a single (HI) limit alarm indicator.

INSTRUCTION MANUAL REVISION

Model 7152, Serial 101 through 105
Model 7153, Serial 101 through 110

The following sections of the instruction manual should be revised as described:

2.4.7 Using an External Clock Signal

Change the first paragraph of this section to read as follows:

> To use an external source of clock signals in place of the internal oscillator, it is first necessary to disable the oscillator circuit in the instrument. The recommended method is to insert a disconnect switch into the oscillator circuit (see dwg. 7000 C 419) between the junction of R403 and C405, and the junction of R402 and R413. When this is done, the external signal can be introduced through the FREQ jack on the back of the instrument. The external signal must have an amplitude of 3 volts rms (into a 3000 ohm load), and can have a frequency as high as 100 kc.

2.5 AUXILIARY CONNECTORS

Change the paragraph pertaining to the "FREQ Jack" to read as follows:

> A sine wave signal of about 10 volts peak-to-peak at the oscillator frequency is available at this jack. An external signal can be introduced at this connector to substitute for the oscillator signal as described in section 2.4.7.

Change the paragraph pertaining to the "TIME Jack" to read as follows:

> The output signal of the clock pulse generator is available at this jack. The signal consists of positive pulses at least 4 volts in amplitude and at least 0.5 microseconds wide. The positive transients are accurately spaced at the interval indicated by the TIME-SECONDS switch. These transients are recommended for external use as a clock signal. The output impedance is 330 ohms.

3.1.2 Adjusting the Shaper Level

Delete the entire section.

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1. INTRODUCTION

1.1 DESCRIPTION

The Limit EPUT® (Model 7152 or 7153) is an electronic counting instrument which signals the fact that a preset number of counts has been reached or exceeded. The Model 7152 provides for a single preset limit, while the Model 7153 allows both a high and a low limit to be selected.

Each preset limit is selected with a set of front panel thumbswitches and can range from 10 to 99,990 counts in 10-count steps. Each limit alarm is signaled by an indicator lamp on the front panel of the instrument. For control of external circuits, a contact opening and closure, operating simultaneously with the corresponding limit alarm, is available at a rear panel connector.

As a counter, the instrument performs several different kinds of counting operations. It will count any series of events which can be translated into voltage changes of a given magnitude; it will count the number of events per unit time, and measure the period between recurring events.

In operation, the instrument repeatedly samples the input signal and displays the count during each sampling by illuminated decimal digits. If the count indication during any sampling period equals or exceeds a preset limit, the corresponding limit alarm is given. The mode of operation, time base interval, and display time are all selected by the operator with front panel controls.

With its built-in test feature, the instrument can be quickly and easily checked for proper operation at any time.

1.2 TECHNICAL CHARACTERISTICS

Input Trigger Channel

Input frequency range

DC to 1mc

Input impedance

10 megohms in parallel with 40$\mu\mu$f

Input sensitivity

100 millivolts rms, 0.3 volts peak-to-peak from DC to 1mc

Input Trigger Channel (cont'd)

Input voltage attenuation

1, 10 or 100 AC and DC

Overload limits

Input impedance drops below 10 megohms when input voltage rises above +1 volt DC after attenuation.

Trigger voltage level

Adjustable from -1 to +1 volts at the attenuated signal

Trigger slope

Plus or minus

Time Base Generator

Clock pulse frequency

Selectable in decade steps from 1 cps to 100 kc

Output signal (available for external use)

Positive pulse 2.5 volts high out of 330 ohms

Oscillator stability

1 part in 10^5 per day

Gating Circuits and DCU's

Paired pulse resolution

5μs

Count capacity

99,999 counts

Display time

Continuously variable from 0.1 to 10 seconds

4-line code from DCU's to external connector

Limit Control Circuit

Preset count limits

Model 7153: High and Low limit, selectable in 10-count steps from 10 to 99,990 counts. (NOTE: High limit setting must be greater than Low limit setting.)

Model 7152: High limit only, selectable in 10-count steps from 10 to 99,990 counts

Limit alarm

Visual indication and output relay operation (one set of form C contacts) at each count limit.

General

Power required
225 watts at 117 v. AC (±10%), 50-60 cps

Size
With cabinet: 20 in. wide, 10 1/2 in. high, 16 in. deep
Without cabinet: 19 in. wide, 8 3/4 in. high, 16 in. deep

Weight

50 pounds (with cabinet)

1.3 APPLICATIONS

The Berkeley Limit EPUT® is useful wherever a variety of precise frequency or time measurements must be made, and checked to see if they fall within specified limits. Thus, the instrument can be used as an electronic "Go, No-go" gauge for production line checking of such items as transmitters, receivers, oscillators, and crystals. With appropriate transducers such as magnetic pickups, photocells and switches, the instrument can be used to monitor many different kinds of process parameters including speed, flow, pressure, etc.

The Dual Limit EPUT® (when modified) can also be used to control the cycling of rotating equipment where operation between two different rotational speeds is required.

A number of accessories which extend the usefulness of the instrument are available. These include the various Beckman/Berkeley transducers, digital recorders, and in-line count indicators.

2. OPERATION

2.1 OVER-ALL DESIGN

The counter will make two types of measurements aside from simple counting:

1) It will count the number of events occurring during a precise time interval. This is known as Events Per Unit Time or E/UT Operation. Frequency measurements are made in this way. The SCAN function is a variation of this operation.

2) It will measure the time interval between two events represented by voltage changes at the input. This is known as PERIOD Operation.

If the events mentioned above are not initially changes in voltage level, appropriate transducers are used to produce voltage changes representing the events at the counter input.

The instrument is composed of the following major functional elements interconnected as shown in Figure 2:

Input Circuit. A circuit which amplifies and properly shapes the signal fed to the instrument.

Time Base Generator. A number of circuits which provide the timing function by generating precisely spaced clock pulses. These pulses control the counting interval in the measurement of events per unit time or are themselves counted in period measurement.

Function Selector. A switching circuit which channels the signals from the two sources (Input Circuit and Time Base Generator) along the proper paths for each mode of operation.

Count Gate. A circuit which controls the passage of input pulses to the counters.

Gate Control Circuits. A number of circuits which provide the signals for opening and closing the Count Gate.

Counters. A chain of decimal counting units (DCU's) which count the pulses passing through the Count Gate.

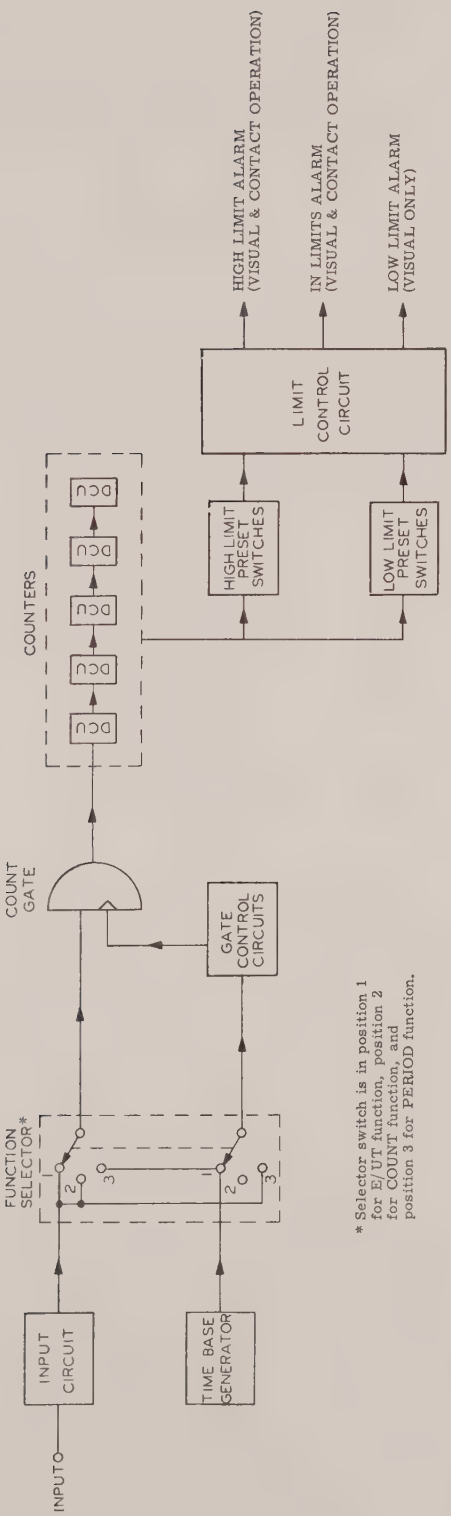


FIG. 2. Simplified functional diagram of the Model 7153. The diagram for the Model 7152 is the same but would show only one block of Preset Limit Switches and one (high) limit alarm output.

Limit Preset Switches. Manual selectors for setting the count limits. (NOTE: The Model 7152 has only one set of limit switches.)

Limit Control Circuit. A circuit which provides the necessary alarm logic and generates the alarm signals.

In addition to those listed, the instrument also includes circuits for resetting the Counters and Gate Control Circuits, as well as a power supply for energizing the entire unit.

2.2 OPERATING CONTROLS AND INDICATORS

FUNCTION switch

1. Interconnects major components to perform the measurement indicated by the setting.
2. Used in manual control of COUNT and SCAN operations.

TIME-SECONDS switch

Selects time interval for E/UT and TEST operations and unit of time measurement for PERIOD operation.

ATTEN(uation) control

Attenuates the signal voltage at the input jack by the factor for which the control is set. When turned to the AC side, only the AC component of the input signal reaches the input trigger channel.

TRIGGER VOLTAGE control

Selects the instantaneous voltage at which the attenuated signal triggers the input channel.

SLOPE switches

Select the slope of the input voltage waveform which triggers the input channel pulse used to operate the gate and control circuitry. See section 2.4, "PERFORMING SPECIFIC OPERATIONS" to determine the function of the SLOPE switches at a particular setting of the FUNCTION switch.

DISPLAY control

Determines how long the instrument holds a reading before resetting and beginning another count. When this control is switched into its "infinity" position, the instrument will hold a reading until the RESET button is pressed.

RESET button

Clears the previous reading and readies the instrument for another counting period.

LIMIT switches

Select the number of counts at which an alarm is given. Model 7153 has HIGH and LOW limit switches; Model 7152 has HIGH limit switches only.

Limit Alarm Indicators

LO lamp indicates that the registered count did not reach the LOW limit setting; HI lamp indicates that the count exceeded the HIGH limit setting; IN lamp indicates that the count fell between the HIGH and LOW limit settings. (NOTE: Model 7152 has HI indicator only.)

2.3 INPUT ADJUSTMENTS

2.3.1 Adjustments for a Sine-wave Input Signal. Whenever the input signal is a sine-wave between 10 cps and 100 kc, and the object is merely to generate one pulse for each cycle without regard for the precise time at which a pulse occurs, the ATTEN(uation) and TRIGGER VOLTAGE controls may be set as follows:

1) Couple the signal to the INPUT jack. Input sensitivity is 100 mv rms (0.3 volts peak-to-peak). Input impedance is 10 megohms.

2) Set the FUNCTION switch at COUNT and press the RESET button. (The SLOPE switches may be in any position.)

3) Rotate the TRIGGER VOLTAGE control slowly from one extreme to the other while the ATTEN(uation) control is at each of the three settings (1, 10 & 100) on the AC side. Note that the instrument will count steadily over a certain range of the TRIGGER VOLTAGE control for each ATTEN(uation) setting. Choose the highest ATTEN(uation) setting at which counting will continue when the TRIGGER VOLTAGE control is rotated through at least 45 degrees.

4) Position the TRIGGER VOLTAGE control at the midpoint of the arc over which counting occurs.

2.3.2 Effect of Input Controls. Figure 3 is a functional diagram of an input trigger channel.

The impedance at the input jack is 10 megohms in parallel with 40$\mu\mu$f. This impedance may be reduced to match the source or to avoid capacitive pickup by attaching a "T" connector to the jack and adding resistors or capacitors in parallel. The input sensitivity is equal to 0.3 volts peak-to-peak times the setting of the ATTEN(uation) control. The input circuitry will take signal amplitudes up to 500 volts peak-to-ground without being damaged.

The attenuator divides the voltage introduced at the input jack by the setting of the ATTEN(uation) control. When the control is set to the "DC" side, the total input signal is attenuated and passed on. When the control is set to the "AC" side, the DC component is removed and only the AC component is attenuated and passed on. Frequencies as low as 1 cps will be passed in the "AC" positions.

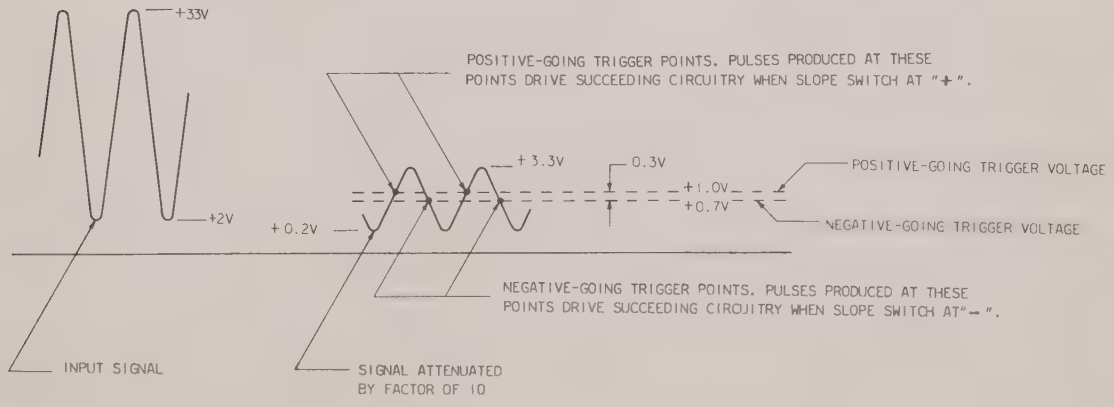

+33V
+2V
+0.2V
POSITIVE-GOING TRIGGER POINTS. PULSES PRODUCED AT THESE POINTS DRIVE SUCCEEDING CIRCUITRY WHEN SLOPE SWITCH AT "+".
+3.3V
0.3V
+1.0V
+0.7V
POSITIVE-GOING TRIGGER VOLTAGE
NEGATIVE-GOING TRIGGER VOLTAGE
NEGATIVE-GOING TRIGGER POINTS. PULSES PRODUCED AT THESE POINTS DRIVE SUCCEEDING CIRCUITRY WHEN SLOPE SWITCH AT"-".
INPUT SIGNAL
SIGNAL ATTENUATED BY FACTOR OF 10

FIG. 4. How an input signal triggers channel output pulses.

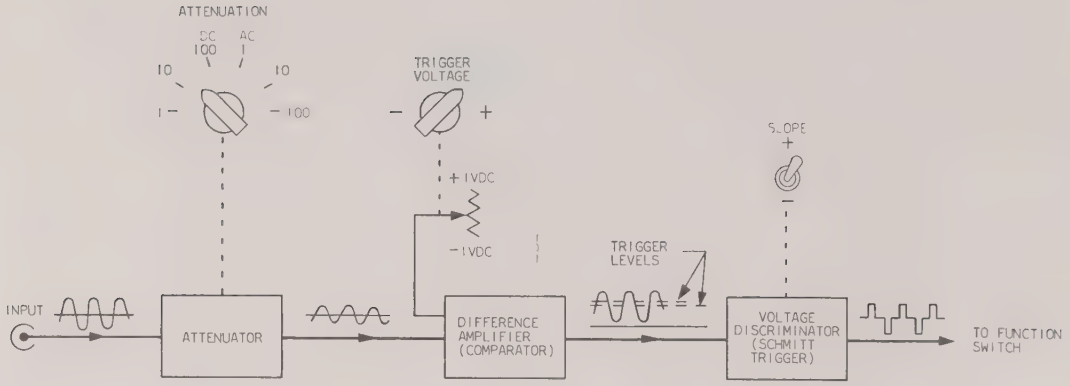


FIG. 3. Functional block diagram of an input trigger channel.

Figure 4 shows how the varying voltage of the attenuated signal triggers channel output pulses. A pulse is produced each time the instantaneous voltage of the attenuated signal passes through the "positive-going trigger voltage" starting from a value more negative than the "negative-going trigger voltage". Another pulse is produced each time the instantaneous attenuated voltage passes through the "negative-going trigger voltage" starting from a value more positive than the "positive-going trigger voltage". When the SLOPE switch is at "plus", only pulses triggered by positive-going voltage excursions affect the succeeding circuitry. With the SLOPE switch at "minus", only pulses triggered by negative-going excursions are effective.

The two trigger voltage levels (positive-going and negative-going) are always separated by 0.3 volts, the effective hysteresis. Because voltage excursion must travel through both levels to trigger a pulse, the sensitivity of the channel to the attenuated signal is 0.3 volts peak-to-peak.

Both trigger levels are raised or lowered simultaneously (maintaining a 0.3 volt separation) when the TRIGGER VOLTAGE control is rotated. This control will vary the levels from roughly -1 volt to +1 volt. Referring to Figure 3, note that the TRIGGER VOLTAGE control actually raises or lowers the DC level of the input to the Voltage Discriminator. This action, however, has the effect of raising or lowering the trigger levels at the input to the Difference Amplifier.

The purpose of the input trigger channel is to produce a reliable pulse output representing that part of the input signal in which the operator is interested. This is achieved only when the ATTEN(uation) and TRIGGER VOLTAGE controls are properly adjusted. Before attempting to adjust the controls, it is best to visualize the input waveform, noting the shape, AC amplitude and DC level. The effect of various control settings is then relatively easy to calculate. Referring to Figure 4, note that:

1) If the attenuated signal has a small peak-to-peak amplitude, the trigger voltage levels may be set so high or so low that no output pulses are produced. In Figure 4, for example, if the "positive-going trigger voltage" were set at -0.5 volts (thus placing the "negative-going trigger voltage" at -0.8 volts), the attenuated signal with peaks at +0.2 and +3.3 volts would not intersect either trigger voltage level.

2) If the attenuated voltage variations are superimposed on a DC level, they may not come within the trigger voltage range. Thus, in Figure 4, if the input signal were not attenuated (or AC coupled) the negative peak at +2 volts would not intersect any possible trigger voltage level.

3) Modulation or variations in the DC level of the attenuated signal are least likely to cause missing of pulses, if the trigger voltages are set about halfway between the peaks of the signal.

4) Extraneous signals (noise, hum, modulation, drift, etc.) have the least effect on the time at which a pulse occurs when the channel is triggered on a steep portion of the waveform.

5) Noise below 0.3 volts peak-to-peak will not trigger extraneous pulses. Consequently, attenuating a signal carrying a given percentage of noise may eliminate the effect of the noise. For example, 1 volt peak-to-peak noise on a 6 volt peak-to-peak signal will trigger extraneous pulses. If the signal is attenuated by a factor of 10, the resulting 0.6 volt p-p signal will still trigger desired pulses dependably, while the resulting 0.1 volt p-p noise is well below the sensitivity of the channel.

6) Attenuating the input signal:

   a) Reduces the slope at all points

   b) Shifts the AC component nearer to ground potential if it is superimposed on a DC level.

c) Increases the minimum peak-to-peak variation needed to trigger pulses (measured at the input jack) from 0.3 volts to 3 or 30 volts.

d) Increases the range of possible trigger voltage setting on the input signal from ±1 volt to ±10 volts or ±100 volts.

Adjustment of ATTEN(uation) and TRIGGER VOLTAGE controls should be made keeping the above characteristics in mind. When using any regular periodic input signal, consistent E/UT or PERIOD readings are a good indication that the controls are properly adjusted.

The point on an input waveform at which the input channel is triggered can be seen on an oscilloscope. Observe the control-grid input to the voltage discriminator in the input channel (V303, pin 2). The waveform which appears is the amplified input signal together with small "notches" created on each slope as the channel is triggered. Rotating the TRIGGER VOLTAGE control will cause these notches to move up and down the waveform. Some information about the position of the trigger voltage relative to the signal may be extracted from the instrument itself. The trigger voltages may be varied between the positive and negative peaks of an attenuated signal whose peaks lie in the range of -1 to +1 volts. As the trigger levels pass beyond the signal peaks, the pulse output of the channel will cease, and then these positions of the control can be noted.

2.4 PERFORMING SPECIFIC OPERATIONS

2.4.1 Measuring Frequency. The frequency of a regular sine-wave signal can be measured either directly under E/UT or E/UT X 10 Operation, or indirectly by measuring the period of the signal and calculating the frequency. The direct method is simpler and should ordinarily be used except when a low frequency signal is to be measured with high accuracy.

2.4.2 Testing for Proper Operation. With the built-in test feature, a quick check can be made to see if the instrument is functioning properly. This should be done routinely just before actual operation is begun, and periodically during extended periods of operation.

To perform a test, proceed as follows:

1) Rotate the DISPLAY control to a point near the extreme counter clockwise position to produce a short display time.

2) Set the FUNCTION selector at TEST.

3) Rotate the TIME-SECONDS selector through each of its settings beginning with "10^{-5}", and note the indicated count obtained at each position. If the instrument is functioning properly, the readings will be as listed in Table I.

Table I. Test Indications

TIME-SECONDS SETTING	CORRECT COUNT INDICATIONS
10^{-5}	00001
10^{-4}	00010
10^{-3}	00100 (±1 count)
10^{-2}	01000 (±1 count)
10^{-1}	10000 (±1 count)
1	00000 (00001 or 99999)

2.4.3 Measuring Events Per Unit Time. In E/UT operation, the unit counts pulses derived from the signal at the input connector during the time that the Count Gate is open. The Count Gate is opened and closed by successive clock pulses from the Time Base Generator. Thus, the counting period is equal to the time interval between clock pulses which, in turn, is determined by the setting of the TIME-SECONDS selector.

To measure events per unit time, proceed as follows:

1) Couple the signal being measured to the input connector.

2) Set the FUNCTION selector at E/UT.

3) Set the TIME-SECONDS selector for the time interval over which counting is to take place.

4) Set the ATTEN(uation) and TRIGGER VOLTAGE controls as described in section 2.3. The SLOPE switches can be left in either position.

5) Set the LIMIT switches for the number of counts at which an alarm is to be obtained. (Note that the LIMIT switches provide for settings to the nearest 10 counts.)

6) Adjust the DISPLAY control so that the count is displayed for a convenient length of time. If each reading is to be displayed until the instrument is manually reset, turn the DISPLAY control into its "infinity" position (as indicated by a switch click).

7) Read the count displayed by the digital indicators. If the TIME-SECONDS selector is set at "1", the reading gives the number of events per second directly. If the TIME-SECONDS selector is at a setting other than "1", divide the reading by the TIME-SECONDS setting to obtain events per second.

2.4.4 Extending the E/UT Measuring Period. With the FUNCTION switch in the SCAN position, the operator can extend the total period over which events are counted, to any multiple of the automatic 1 second period. To use the SCAN mode of operation, proceed as follows:

1) Follow steps 1 through 5 of section 2.4.3 ("Measuring Events Per Unit Time"), but set the TIME-SECONDS selector at "1".

2) Rotate the DISPLAY control clockwise into its "infinity" position (as indicated by a switch click).

3) Press the RESET button. The instrument will automatically begin a 1 second counting period. Before the end of this period, turn the FUNCTION selector to SCAN and begin timing a period equal to the total counting time wanted minus one automatic counting period (1 second). For example, if the counting time wanted is 30 seconds, the interval to be timed is 29 seconds.

4) At the end of the interval being timed, turn the FUNCTION selector back to E/UT. When the instrument stops counting, read the count displayed by the digital indicators.

(NOTE On instruments equipped with the "B" modification, the SCAN mode also provides for counting periods which are multiples of 10 seconds In that case, the E/UT X 10 position of the FUNCTION switch is used instead of E/UT.)

2.4.5 Measuring a Period. In the PER(iod) mode, the unit counts the number of clock pulses from its Time Base Generator which go through the Count Gate while it is open. The gate, in this case, is controlled by the signal at the input jack, and is alternately opened and closed each time that signal passes through a certain voltage level. Since the clock pulses mark certain precise intervals of time, the count indicated by the instrument represents the elapsed time during which the gate was open. Consequently, this is the period of the recurring events represented by voltage changes at the input connector.

To make a period measurement, proceed as follows:

1) Couple the signal being measured to the input connector.

2) Set the FUNCTION selector at PER.

3) Set the TIME-SECONDS selector for the time unit in which the period is to be measured. For example, with the selector at "10^{-4}", the period is measured in units of .0001 seconds. The smaller the time unit chosen, the more accurate the readings.

4) In the PER(iod) mode, the START SLOPE switch selects the polarity of the input voltage excursion which begins the timing period. The STOP SLOPE switch selects the polarity of that which ends the timing period. Consequently, the SLOPE switches should be set as follows:

   a) When measuring the period of a wave, set both SLOPE switches to "plus" or both to "minus".

   b) When measuring the width of a positive pulse, set the START SLOPE switch to "plus" and the STOP SLOPE switch to "minus".

   c) When measuring a negative pulse, set the START SLOPE switch to "minus" and the STOP SLOPE switch to "plus".

5) Set the ATTEN(uation) and TRIGGER VOLTAGE controls as described in section 2.3.

6) Set the LIMIT switches for the number of counts at which an alarm is to be obtained.

7) Adjust the DISPLAY control so that the count is displayed for a convenient length of time. If each reading is to be displayed until the instrument is manually reset, turn the DISPLAY control into its "infinity" position (as indicated by a switch click).

8) Read the count displayed by the digital indicators. To obtain the length of the period in seconds, multiply the reading by the TIME-SECONDS setting.

2.4.6 Counting Events. In the COUNT mode, the unit continually counts pulses derived from the signal at the input connector as long as the FUNCTION selector remains in the COUNT position. Since the Time Base Generator is not used in this mode of operation, the count indicated by the instrument is merely a tally of the total number of events which have occurred. Moreover, the limit circuitry does not function in this mode.

To count events, proceed as follows:

1) Couple the signal being counted to the input connector.

2) Set the ATTEN(uation) and TRIGGER VOLTAGE controls as described in section 2.3. The SLOPE switches can be left in either position.

3) Set the FUNCTION selector at OFF.

4) Press the RESET button to clear the digital indicators.

5) Turn the FUNCTION selector to COUNT to start counting.

6) Turn the FUNCTION selector to OFF to stop counting.

7) Read the count displayed by the digital indicators. To resume counting without clearing the accumulated count indication, turn the FUNCTION selector back to COUNT without pressing the RESET button.

2.4.7 Using an External Clock Signal. For time base intervals other than those available on the instrument, an external source of clock signals can be used in place of the oscillator in the Time Base Generator. To do this, couple the external clock signal to the connector labeled FREQ on the back of the instrument, and put the EXT-INT switch in the EXT position. If the frequency of the external signal is different from that of the internal oscillator, the TIME-SECONDS selector must be set in the "10^{-5}" position. Under these conditions, clock pulses can be obtained only at the frequency of the external signal.

The external signal must have an amplitude of 3 volts rms (into a 3000 ohm load); it can have a frequency as high as 100 kc.

NOTE

At frequencies much lower than 1 kc, capacitor C401 (dwg. no. 7000 C 419) may attenuate the signal below the usable level. In such a case, this capacitor should be shorted with a jumper wire and a larger capacitor connected between the signal source and the FREQ connector.

2.5 AUXILIARY CONNECTORS

Each of the following connectors is located on the rear panel of the instrument.

ACCESSORY Socket. External circuits connected to this socket are controlled simultaneously with the limit alarm indications as follows:

	Model 7152	Model 7153
HI Limit Alarm:	Pins A-I open circuit Pins B-I close circuit	Pins C-J open circuit Pins D-J close circuit
IN Limits Alarm:	----	Pins A-I open circuit Pins B-I close circuit

Pins E and F (on both models) are connected to the AC power line.

TIME Jack. The output signal of the clock-pulse generator is available at this jack. The signal consists of positive pulses 25 volts in amplitude. The positive transients are accurately spaced at the interval indicated by the TIME-SECONDS switch. These transients are recommended for external use as a clock signal. The negative transients occur at the same frequency but are not so accurately spaced. The output impedance is 330 ohms.

FREQ Jack. A sine-wave signal at the oscillator frequency is available at this jack when the EXT-INT switch is at INT. The signal is 10 volts peak-to-peak out of 3000 ohms. When the EXT-INT switch is at EXT., an external signal can be introduced at this jack to substitute for the oscillator signal as described in section 2.4.7 .

SCOPE Jack. The voltage at this jack indicates the state of the signal gate in the instrument. This voltage is about -45 v with respect to ground when the gate is closed, and at approximately ground level when the gate is open. An oscilloscope connected to this jack will display a square wave whose width corresponds to the length of time the gate is open or, in other words, to the counting period.

DIGITAL RECORDER Socket. Each DCU generates a four-line code representing the digit it is displaying. These lines terminate at the DIGITAL RECORDER socket at the rear of the instrument. The Model 1452 Digital Recorder plugs directly into this socket. The socket also makes mutual control connections between the counter and the recording device.

In addition, the socket is wired so that the recorder will print an indicator digit to show that the corresponding number of counts is outside the preset limit. Thus, a "1" ahead of the highest order digit indicates that the number is less than the LOW limit; a "3" indicates that the number is above the HIGH limit. When a number falls within the preset limits, no indicator digit is printed.

The four-line code is shown in Table I. In the tabulation, a "0" represents a negative potential of 15 volts or more with respect to ground; a "1" represents a potential at ground level or somewhat positive with respect to ground.

Table I. Four-Line Binary Code

DECIMAL DIGIT REGISTERED	FIRST BINARY STAGE	SECOND BINARY STAGE	THIRD BINARY STAGE	FOURTH BINARY STAGE
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	1	1	0
5	1	1	1	0
6	0	0	1	1
7	1	0	1	1
8	0	1	1	1
9	1	1	1	1
No Digit	0	0	1	0

Table II gives the pin numbers on the DIGITAL RECORDER socket for the four binary lines of each decimal digit position.

Table II. Identification of Pin Numbers on Digital Recorder Socket

ORDER OF DIGIT READ	FIRST BINARY STAGE	SECOND BINARY STAGE	THIRD BINARY STAGE	FOURTH BINARY STAGE
Highest	Pin 4	Pin 3	Pin 2	Pin 1
Second	8	7	6	5
Third	12	11	10	9
Fourth	16	15	14	13
Fifth	20	19	18	17
Sixth *	24	23	22	21

NOTE

Pins 25 through 28 are wired to produce a limit indicator digit ("1" or "3") ahead of the highest order count digit. Pin 36 provides a negative voltage from the recorder for generating the limit digit code.

Pin 39 carries a control signal from the counter. This pin is negative during the display period and positive from reset until the end of the next counting period.

Pin 40 is the "inhibit reset" line. When this pin is grounded the counter cannot reset.

Pin 38 is grounded; pins 29 through 35 and pin 37 remain unconnected.

*On instruments having only five indicating DCU's, these pins are permanently wired to produce the "no digit" code, 0010.

3. SERVICING

3.1 ROUTINE ADJUSTMENTS

3.1.1 Adjusting the Oscillator Frequency. The frequency of oscillation can be adjusted by a small amount with the XTAL ADJ control at the top of the chassis. To make this adjustment, rotate the control until the oscillator signal at the FREQ jack produces a zero beat with a signal from WWV or some other highly accurate frequency standard. The Beckman/Berkeley Model 905 WWV Receiver, which operates at any of the six standard WWV frequencies, is especially useful for this adjustment.

NOTE

Whenever the oscillator crystal is replaced, it may be necessary to change capacitor C404 so that the frequency of oscillation can be adjusted to the correct value.

3.1.2 Adjusting the Shaper Level. The shaper stage in the time base generator is a voltage discriminator similar to that in the Input Trigger Channel. The SHAPER LEVEL control, located on the top side of the counter chassis, sets the trigger voltage at the input to this circuit. To adjust, set the FUNCTION switch at TEST. Find the limits of the range of adjustment over which the instrument continues to count. Set the control at the mid-point of this range.

3.1.3 Adjusting the Regulated 120 Volt Supply. Measure the supply voltage at the test point labeled "+120V" with an accurate voltmeter. If necessary, adjust the +120V ADJUST control, located at the rear of the instrument, for a reading of 120 volts.

3.1.4 Adjusting the Frequency Dividers*. If the instrument fails to indicate correctly with the FUNCTION switch at TEST, one or more dividers may be out of adjustment. Dividers should be adjusted using the potentiometer controls located under the top cover of the cabinet and labeled "ADJ 1 SEC; ADJ 10^{-1} SEC;" etc. To adjust, set the FUNCTION switch at TEST, and proceed as follows:

1) Turn TIME-SECONDS switch to 10^{-4} and measure the DC voltage between test point E4 and ground. Rotate the ADJ 10^{-4} SEC control to the extremes of the range in which a reading of 10 is

*Before making this adjustment, always check the regulated 120 volt supply as described in section 3.1.3.

1) (cont'd)

displayed by the DCU indicators. Note the test point voltage at each extreme, and then adjust the control until the test voltage is midway between the extreme values.

2) Turn TIME SECONDS switch to 10^{-3} and measure the voltage at E3. Rotate the ADJ 10^{-3} SEC control to the extremes of the range which gives a count reading of "100", noting test point voltages at the extremes. Adjust the control until the voltage is midway between extreme values.

3) With the TIME SECONDS switch at 10^{-2}, set ADJ 10^{-2} SEC control similarly but to center of voltage range in which either 1000 or 999 appears.

4) Adjust the remaining controls in order to the center of the 10,000 or 9,999 range, and the 100,000 or 99,999 range.

The adjustment of each divider affects the adjustment of the others slightly. Therefore, after the initial adjustment outlined above, a final adjustment should be made. With the FUNCTION switch at TEST, set the TIME-SECONDS switch to 10^{-1}; a reading of 10,000 or 9,999 will appear. Adjust, in turn, the ADJ 10^{-4} SEC thru ADJ 10^{-1} SEC controls to the center of the corresponding test point voltage range within which either of these readings appears. Then turn the TIME-SECONDS switch to 1 and rotate the ADJ 1 SEC control to the center of the voltage range at E0 within which either 100,000 or 99,999 appears.

3.1.5 Adjusting the Input Attenuators. The two ceramic trimmer capacitors on the input attenuator assembly must be adjusted properly to prevent the attenuator from distorting the input signal. With the counter chassis upside down and the attenuator shaft pointing toward the viewer, the capacitor on the right side of the attenuator is C303 and that on the left is C302. To adjust, apply a 500 cps square wave signal at the front panel input jack. Observe the corresponding amplifier output at Pin 1 of V302 with a 100 kc band-width oscilloscope. Turn the ATTEN(uation) control to 10 on the AC side. Adjust the input signal to about 1 volt peak-to-peak. Adjust the TRIGGER VOLTAGE control to any position in which the channel triggers. Adjust C303 for a square wave output. Then, turn the ATTEN(uation) control to 100 on the AC side and adjust the input signal to about 10 volts peak-to-peak. Adjust C302 for a square wave output.

Modified instruments are identified by a letter or letters after the model number. For example, the Model 7150D is a standard Model 7150 EPUT® Meter modified as described below under "Modification D". An instrument may be modified in more ways than one; for instance, the Model 7150DK is a Model 7150 changed in accordance with both "Modification D" and "Modification K".

MODIFICATION B

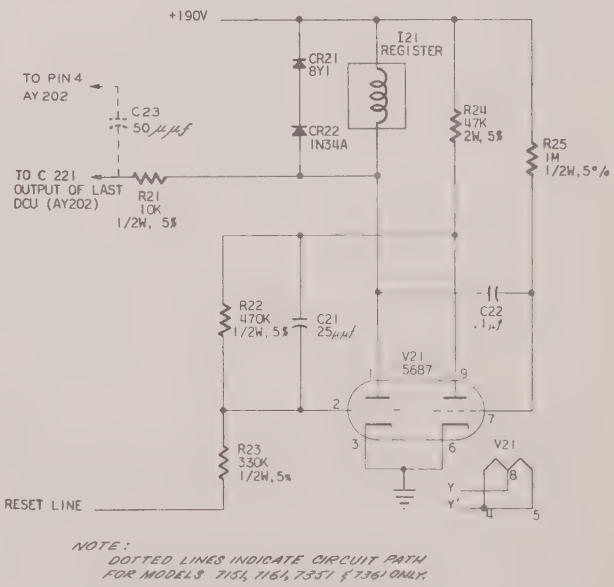
This consists of adding a dual-purpose decimal counting unit to 7000 series instruments which do not normally contain such a unit. Depending on the position of the FUNCTION switch, this DCU either extends the count capacity by a factor of 10 or divides the frequency of the pulses which start and stop counting by 10.

MODIFICATION C

This consists of the addition of a mechanical register which will extend the counting capacity of any 7000 series instrument by a factor of 10^3. Instead of using the electronic signal which resets the DCU's, the register is reset by a small lever on the front panel directly below the mechanical count-indicating dials.

On instruments with "X10" positions on the FUNCTION switch, the indicating panel of the DCU Divider (AY201) is not exposed to view when the C modification is made. The digit normally displayed by AY201 is shown at the right-hand digit of the register dial. AY202, the last exposed DCU next to the register, drives V21, a one-shot multivibrator. Each time this is activated a count is recorded on the mechanical register, the coil of which is the multivibrator plate load.

When AY202 resets, a counting pulse may appear in the output. To counteract this, the reset line is connected to control-grid pin 2 of V21, so that whenever a reset pulse causes a count from AY202 to appear on the plate pin 1 of V21, the reset pulse also appears at the grid. The two pulses, opposite in polarity, counteract each other so that no count is recorded at the register.

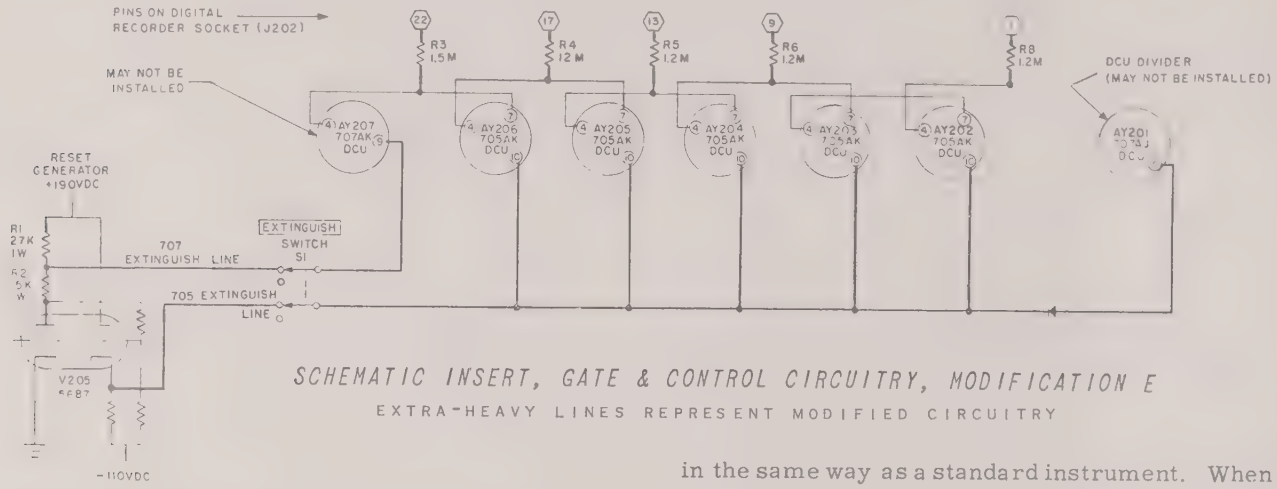


SCHEMATIC INSERT, GATE & CONTROL CIRCUITRY, MODIFICATION C

MODIFICATION D

This consists of substituting a 100Kcs heated crystal in the oscillator of the clock-pulse generator in place of a 100Kcs unheated crystal. This modification is applicable only to 7000 Series instruments which normally contain an unheated crystal (for example, Models 7150 and 7250). The heated crystal has a stability of 1 part in 10^6 per day as compared with a stability of 1 part in 10^5 per day for the unheated crystal.

MODIFICATION E



SCHEMATIC INSERT, GATE & CONTROL CIRCUITRY, MODIFICATION E

EXTRA-HEAVY LINES REPRESENT MODIFIED CIRCUITRY

This consists of replacing the standard decimal counting units with DCU's whose indicating bulbs can be extinguished automatically while the instrument is actively counting. With automatic extinguishing, the indicating bulbs light only at the end of each counting period to display the result.

The accompaning schematic insert shows how the circuitry of the standard instrument is modified. The voltage which extinguishes the DCU bulbs is supplied by the reset generator while it functions as usual in the standard automatic operating cycle. Both "extinguish lines" leading from the reset generator are at a relatively negative voltage at all times except during the display period. The relatively-negative voltage applied to the DCU's prevents the neon bulbs from lighting. The relatively-positive voltage on the "extinguish lines" during the display period permits the bulbs to light.

The EXTINGUISH toggle switch is located on top of the counter chassis. It may be exposed by lifting the top lid of the instrument. When this switch is closed the indicating bulbs are automatically extinguished as described above. When the switch is open the counter operates in the same way as a standard instrument. When counting is controlled manually (that is, by moving the FUNCTION switch from OFF to COUNT and back again) the EXTINGUISH switch should be open. Under manual control no automatic display period occurs, so the reset generator always supplies a voltage which would extinguish the indicating neons if connected to the DCU's.

All 705AH DCU's in the standard instrument are replaced by 705AK DCU's. Pin 10 of the DCU socket is connected to an "extinguish line" instead of to a pin in the DIGITAL RECORDER socket. The DIGITAL RECORDER pin which ordinarily connects to pin 10 is connected instead to pin 4 through a 1.2 megohm resistor.

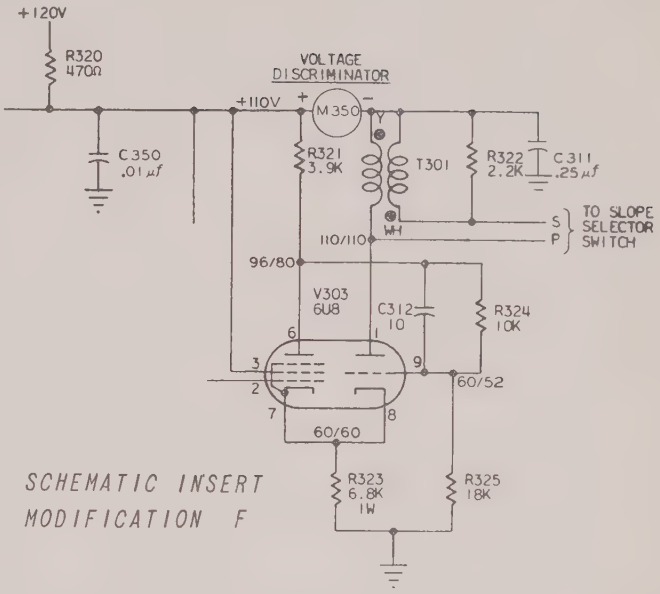
If the standard instrument has a maximum counting rate of 1 Mcs, it contains a 707AH DCU. This DCU is replaced by a 707AK DCU. An "extinguish line" is connected to pin 9 of the DCU socket, and the DIGITAL RECORDER pin which is ordinarily connected to pin 9 is connected instead to pin 4 through a 1.5 megohm resistor.

If the standard instrument is equipped with a DCU used as both a counter and a frequency divider (Model 705AJ), an "extinguish line" is connected to pin 10 of its socket.

MODIFICATION F

This consists of making modifications B, D and R plus adding a TRIGGER STATE meter to the E/UT input channel. The meter aids in adjusting the TRIGGER VOLTAGE control. The operator should adjust this control until the meter pointer stays in the center green region.

The TRIGGER STATE meter actually indicates the plate current flowing in the output triode of the voltage discriminator in the E/UT channel. This stage has two stable states: cut-off and conducting heavily. When the triode is cut-off, the meter indicates zero; when it is conducting, the meter is deflected to approximately full scale. The triode is triggered from one state to the other and back again by each input signal cycle. If the input frequency is above 10 cps the inertia of the meter will cause it to indicate the average plate current. A meter reading in the center green region indicates that the triode is cut-off half the time and conducting the other half. Under these conditions the channel produces the most reliable pulse output to be counted on the DCU's.

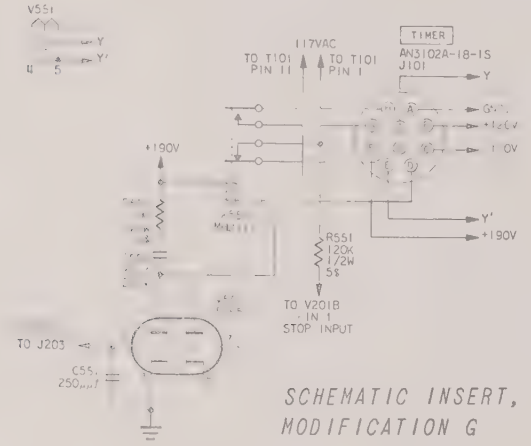


SCHEMATIC INSERT
MODIFICATION F

MODIFICATION G

This modification provides connections so that an external timer can be used to extend the sampling time of the counter. The labeling of J101 is changed from "ACCESSORY" to "TIMER". This socket provides 117 volt ac for operating the timer motor and it provides ground and Control Binary stop-input pin connections to the time-delay switch in the timer.

The G Modification functions with a timer in this manner. The timer dial is set to indicate a certain

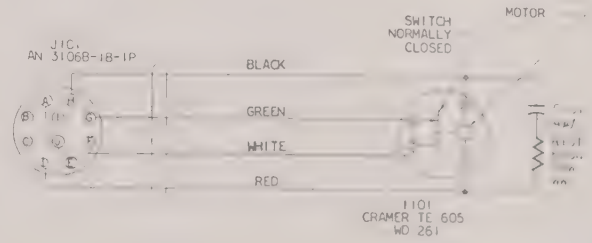


SCHEMATIC INSERT, MODIFICATION G

interval of time. A switch in the timer grounds the stop-input pin (pin 1, V201B) of the Control Binary (V203), so that once the counter starts counting it will not stop until the stop-input pin is ungrounded. The Relay Control tube (V501) conducts and energizes relay K501 when the Signal Gate (V204) "opens". (V501 is caused to start and stop conducting by the same signals that "open" and "close" the Signal Gate--that is, the output of the Control Binary.) When the relay energizes, it closes the contacts which supply 117 volts ac to energize the timer motor. After the pre-determined time interval, the time switch opens, and the Control Binary stop-input pin is removed from ground. The next clock pulse causes the Control Binary to "close" the Signal Gate and cut off the Relay Control tube (V501). K501 is de-energized, its contacts open and remove the power from the timer motor. At this point, the timer resets.

When the external timer is not used, remove the cable from the TIMER socket and the counter will operate normally.

The modified instrument is designed to be used with the Model 806 Timer. The timer will extend the 10-second automatic counting period to 20, 30, 40, 50 or 60 seconds. To install, simply connect timer plug to the TIMER socket at the rear of the counter. When operating, be sure the counter is set up to generate 10-second automatic counting period; that is, with the FUNCTION switch at E/UT x 10 and the TIME switch at "1". Set the timer to approximately 5 seconds less than the total counting period desired. Adjust the counter display time to one second or longer. If you find occasion to reset the instrument manually before the expiration of the extended counting period, depress the RESET button repeatedly until you see that the running pointer has returned to its starting position.

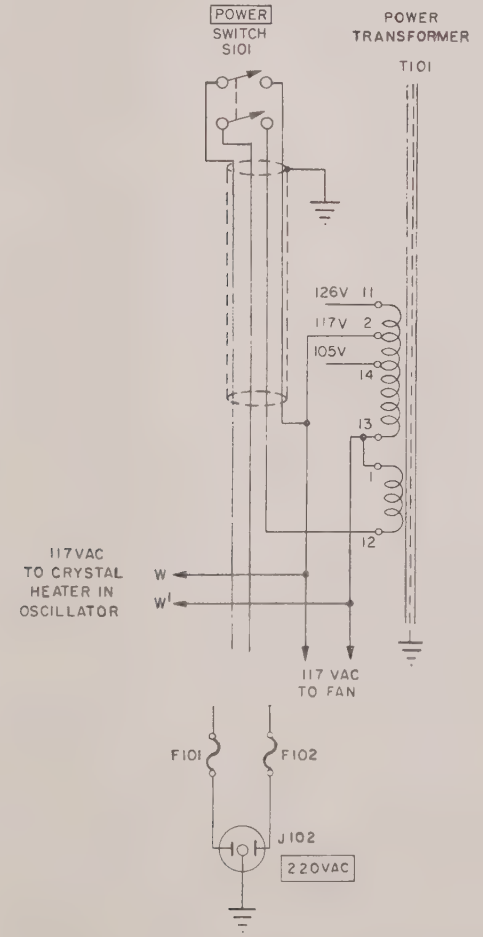


TIMER SCHEMATIC DWG. NO. 806 A 1

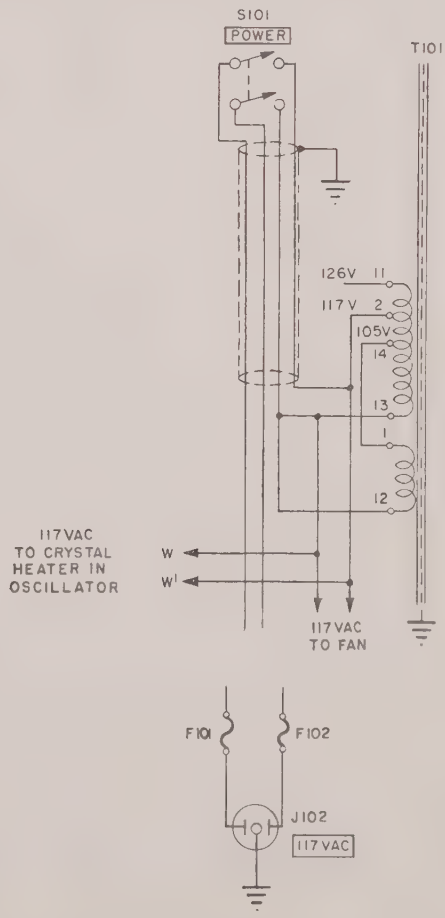
MODIFICATION H

This consists of modifying the instrument so it can be operated off a 220-volt line. The standard 117-volt power transformer is replaced by transformer having two primary windings, a 117-volt winding and a 105-volt winding. As shipped, these windings are connected in series so that when the instrument is connected to a 220-volt line, the proper voltage appears across each winding. The schematic insert below shows the modified circuitry. The line fuses (F101 & F102) in the standard counter have been replaced by fuses of one-half the standard current rating. Note that the crystal oven in the oscillator will no longer begin heating as soon as the instrument is plugged in, but will heat only when the POWER switch is on.

An instrument modified to operate on 220 volts can be reconverted to operate on 117 volts by changing the connections to the primary of the power transformer (T101) and replacing the line fuses. To do this break the connection between transformer terminals 1 and 13 and connect terminal 1 to terminal 14 and terminal 13 to terminal 12. Replace line fuses F101 and F102 with fuses of twice the current rating of those installed. The resulting circuitry is shown in the schematic insert below. Note that the 117-volt winding is connected across the line and that the 105-volt winding is connected in parallel with part of the 117-volt winding.



SCHEMATIC INSERT, POWER SUPPLY, MODIFICATION H



SCHEMATIC INSERT, POWER SUPPLY, MODIFICATION H RECONVERTED TO OPERATE ON 117 VOLTS AC.

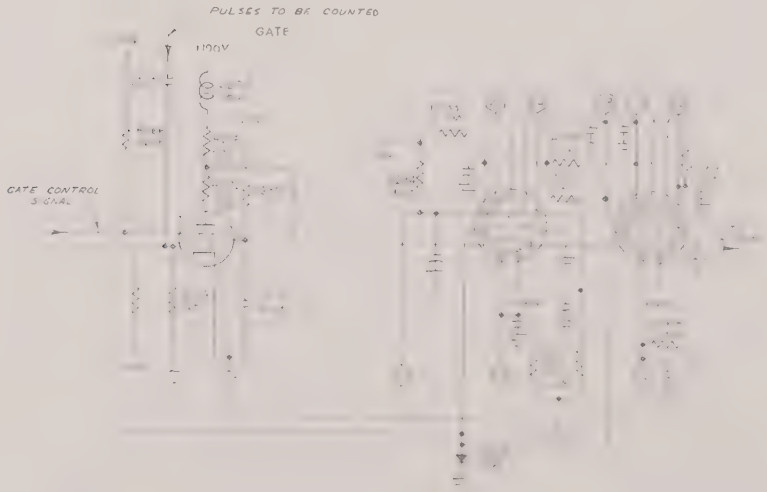
MODIFICATION J

The purpose of this modification is to increase the maximum counting rate from 1Mcs to 2Mcs. To do this the first two DCU's in the counting chain are replaced with higher speed units and both input channels are modified to extend the frequency range of each to 2Mcs.

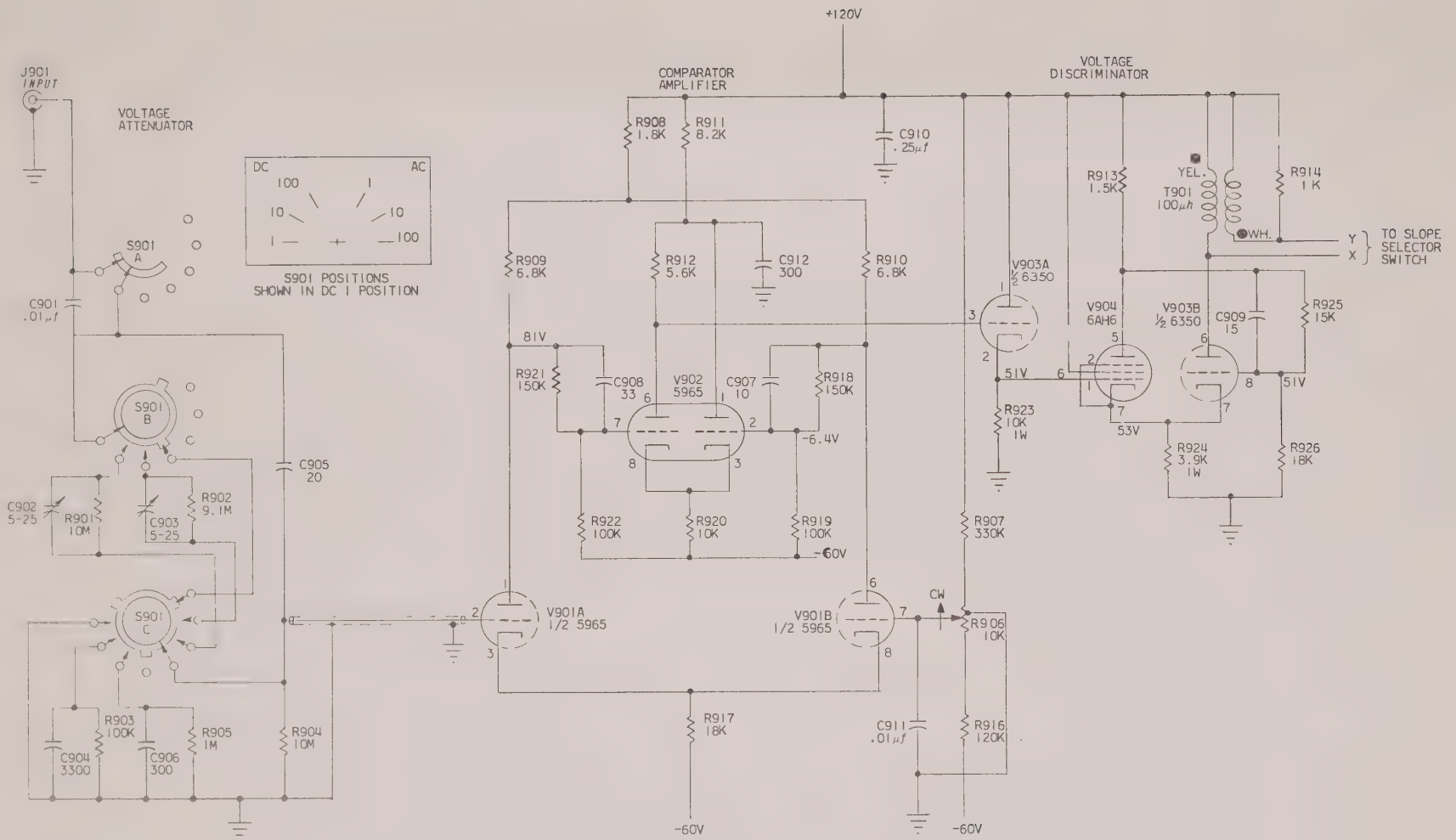
The new DCU's are the Model 711AH, which replaces a Model 707AH as AY207, and the Model 713AH, which replaces a Model 705AH as AY206. Instruction manuals on the new DCU's are located at the rear of this booklet. To accomodate this change, the circuitry surrounding the new DCU's and the gate circuitry is modified slightly, as shown in the accompanying schematic insert.

The frequency response of the input channels has been extended by inserting a cathode follower between the difference amplifier and the voltage discriminator. A schematic diagram of the modified channel appears on the following page.

(NOTE: On the Model 7360 Universal EPUT® and Timer, this modification includes the addition of an accessory socket as described under "MODIFICATION U".)



SCHEMATIC INSERT, GATE & CONTROL CIRCUITRY
MODIFICATION J



NOTE:

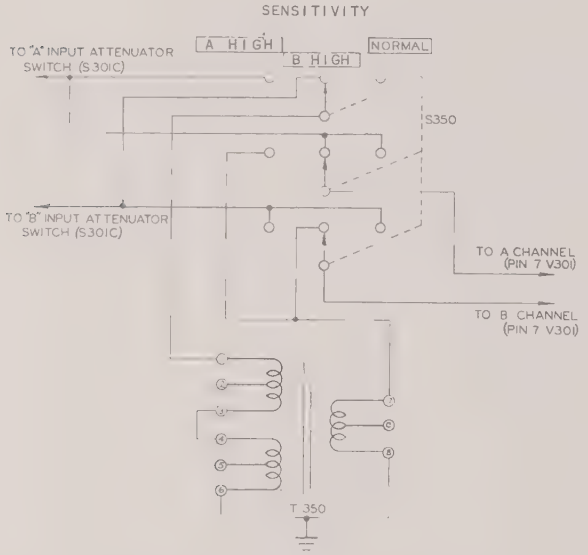
RESISTORS: 1/2 WATT, 5% UNLESS OTHERWISE NOTED.

CAPACITORS: IN μμf UNLESS OTHERWISE NOTED.

SCHEMATIC DIAGRAM
INPUT TRIGGER CHANNEL
MODIFICATION J.
DWG NO. 5571C7

MODIFICATION K

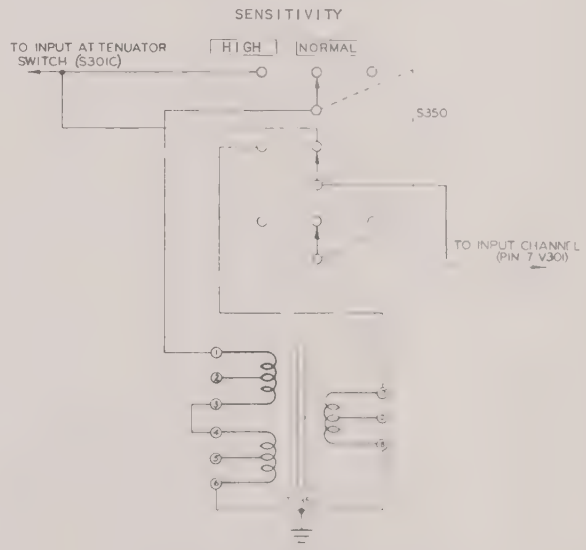
The purpose of this modification is to increase the input sensitivity of the counter from 100mv rms to 5mv rms with a resultant decrease in input impedance. This is done by adding a step-up transformer in the input circuit. The operator may insert and remove the transformer by positioning a front-panel sensitivity switch.



WIRING FOR TWO INPUT CHANNELS

If the modified instrument has two input channels, the front-panel switch will have three positions marked "NORMAL", "A HIGH" and "B HIGH". At NORMAL the transformer is not connected to either input channel, and the instrument functions just as though it had not been modified. At A HIGH the step-up transformer is connected between the attenuator and the input grid of the A channel. At B HIGH the transformer is inserted between the B attenuator and the input grid of that channel. If the modified instrument contains only one input channel the front-panel switch has only two positions; one marked "NORMAL", the other marked "HIGH".

Do not insert the transformer in an input channel unless the input signal is below the normal sensitivity of the counter. With the transformer connected, the ATTENUATION control should be at DC-1. Under these conditions the input impedance will vary with frequency, rising from at least 300 ohms at 5cps to approximately 25K ohms at 10Kcs. Sensitivity is at least 5mv over this frequency range.



WIRING FOR ONE INPUT CHANNEL

MODIFICATION L

This modification makes it possible to set the digital divider number (N) on a preset counter (Model 7151, 7161, 7351, or 7361) either at the front panel of the instrument or at a remote point. The modification includes the following changes made in a standard instrument.

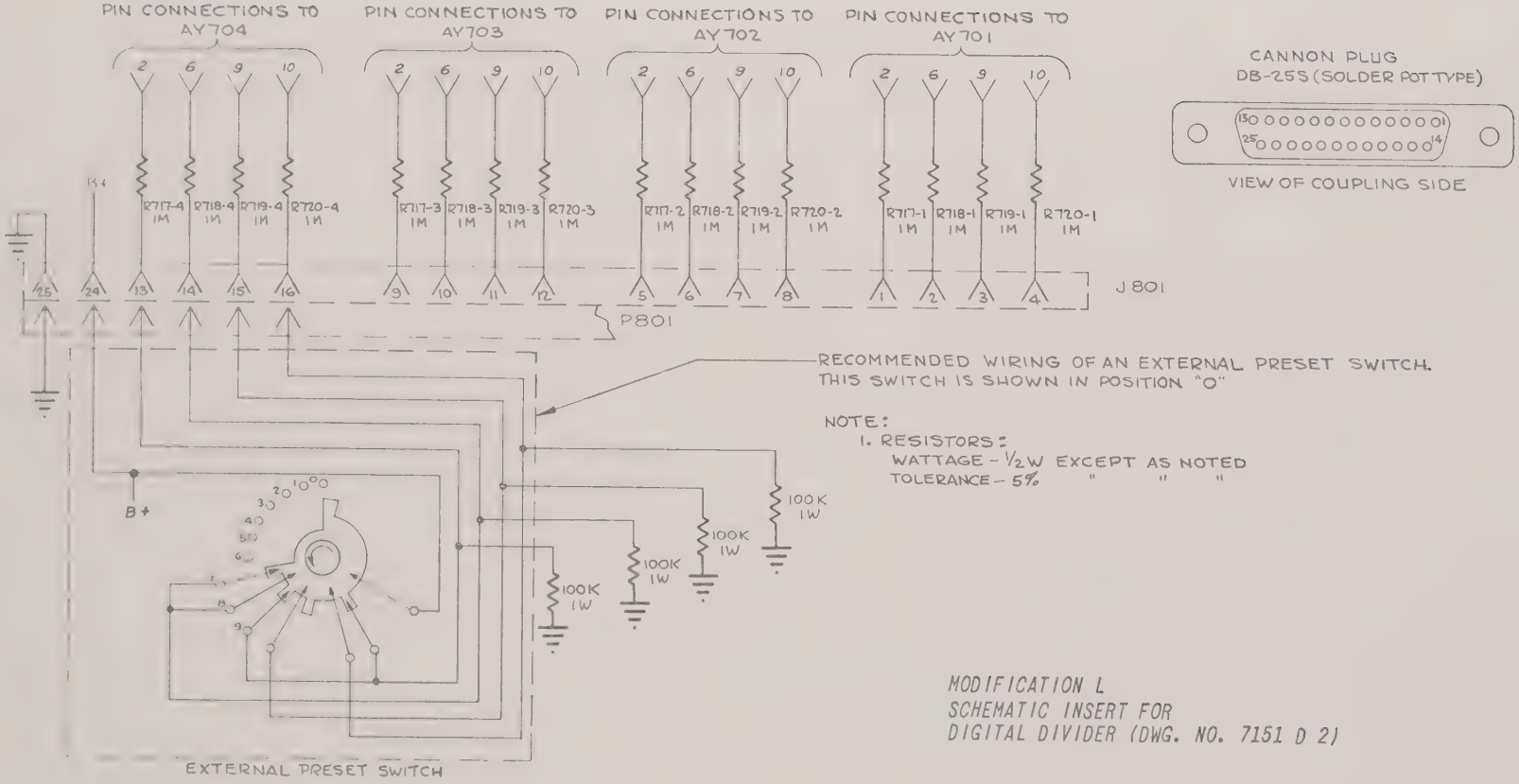
A 25-pin female connector (J801) has been added on the rear of the chassis. This connector is wired to the sockets of the digital divider DCU's as shown on the schematic insert for this modification.

One end of a length of ribbon cable has been wired to the preset switches mounted on the instrument. The other end of this cable, terminated by a 25-pin male connector (P801), extends from the rear of the unit and plugs into the chassis connector.

Another 25-pin male connector is provided for wiring to the external preset switches (see schematic insert).

To control the digital divider from the remote preset switches, unplug the ribbon cable connector at the right rear of the chassis and plug in the connector wired to the remote unit. To return control of the divider to the front panel thumbswitches, merely reverse the procedure.

See following page for schematic diagram.

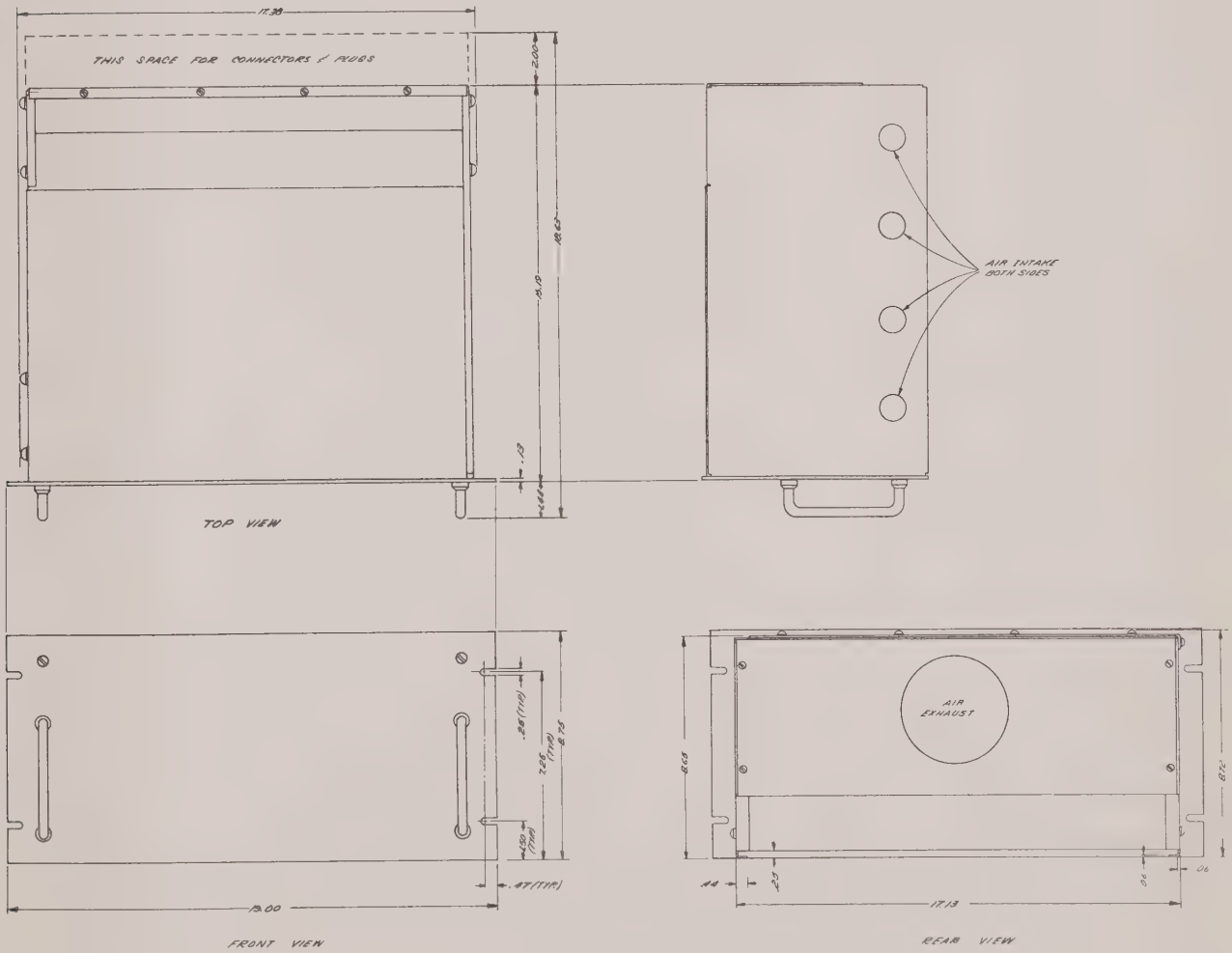


MODIFICATION L
SCHEMATIC INSERT FOR
DIGITAL DIVIDER (DWG. NO. 7151 D 2)

MODIFICATION R

In this modification, the instrument is supplied without a cabinet but with a dust cover on top of the chassis. This allows the unit to be installed and operated in a standard relay rack. Mounting dimensions are as shown in the figure below.

Cooling air is drawn into the unit through a set of intake ports near the bottom of both sides of the chassis. These should remain relatively unobstructed to allow a free flow of air. The same holds true for the exhaust opening in the back of the unit.



RACK MOUNTING DIMENSIONS,
MODIFICATION R

MODIFICATION T

This consists of the V modification plus a half-second clock-pulse interval in place of the usual one-second interval. The last stage of the Frequency Divider Chain is modified from a divide-by-ten to a divide-by-five stage. This is done by changing the value of timing capacitor C617 from 0.47μfd to 0.25μfd. The extreme clockwise position of the TIME-SECONDS switch is also changed to read ".5". When using an instrument with this modification keep in mind that the maximum sampling time available is 0.5 seconds, not 1.0 seconds.

MODIFICATION U

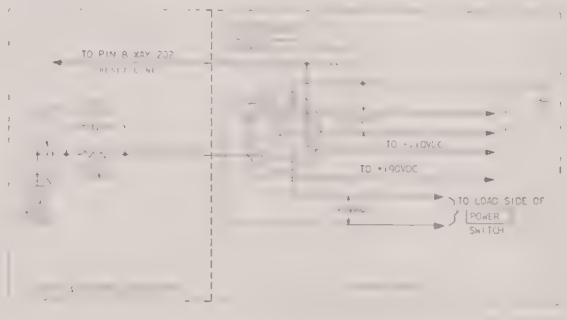
This consists of adding an accessory socket to the rear panel. The socket carries ac and dc voltages which can be used to power auxiliary equipment.

Pin No.	Voltage
A	Ground
B	+120v dc reg.
C	-110v dc unreg.
D	Spare
E	6.3v ac (gnd. side)
F	+200v dc unreg.
G	Spare
H	Spare
I	6.3v ac (hot side)
J	Spare

MODIFICATION V

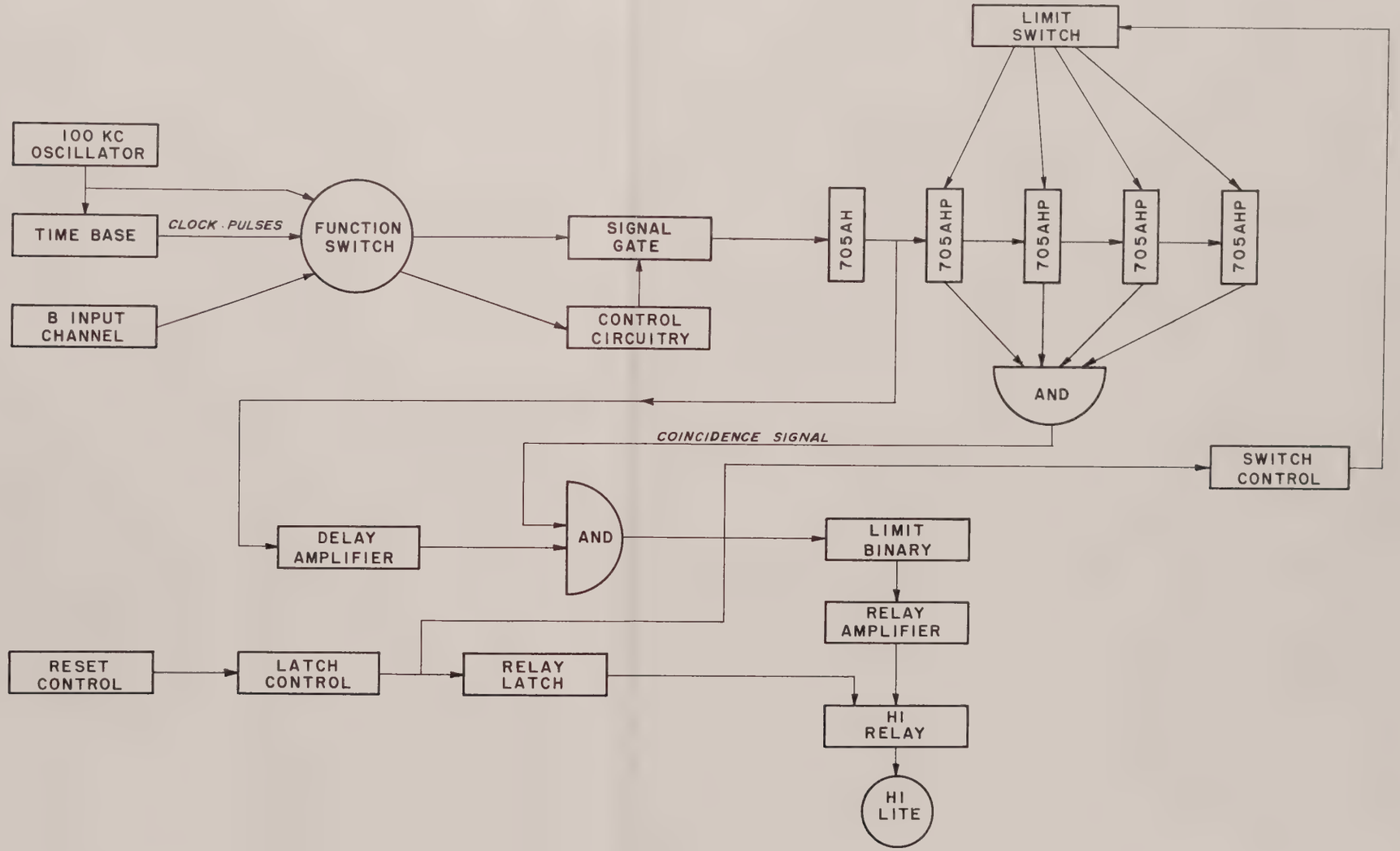
The V modification provides DCU Drive and Reset signals, as well as power at the ACCESSORY socket (J101) for operating a remote indicator consisting of several cascaded DCU's. The DCU drive signal is taken from the plate of the Signal Gate (V204). The signal is passed through a network which reduces its amplitude and its output impedance before it reaches the ACCESSORY socket. The Reset signal is taken directly from the reset line (pin 8 of the DCU's). In addition, B+ and B- voltages are available at J101, as well as 117 volts ac to power a fan and a filament transformer.

The DCU's may be removed from the counting instrument and placed in the remote indicator. If this is done there will no longer be a signal at J202, the DIGITAL RECORDER socket, for operating an accessory recorder. With the remote indicator in use, operate the counting instrument in the usual manner. When the remote indicator is not used, disconnect the indicator cable from the ACCESSORY socket.



SCHEMATIC INSERT, MODIFICATION V

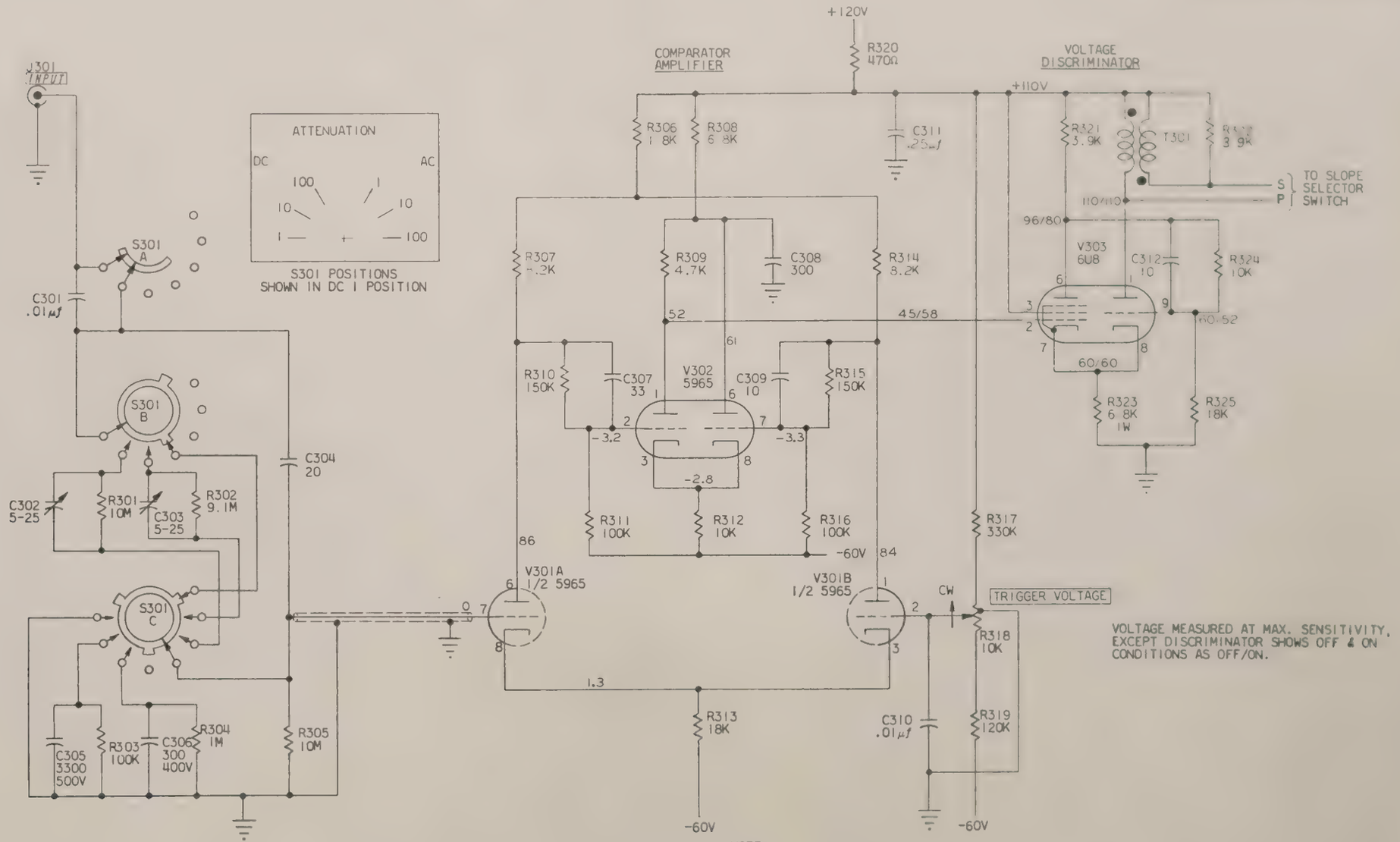
MODEL 7152 LIMIT EPUT
LOGIC DIAGRAM



Oct 1959

BECKMAN/BERKELEY DIVISION
DWG. NO. 7152 C 4

INPUT CHANNEL SCHEMATIC DIAGRAM



VOLTAGE MEASURED AT MAX. SENSITIVITY, EXCEPT DISCRIMINATOR SHOWS OFF & ON CONDITIONS AS OFF/ON.

NOTE:

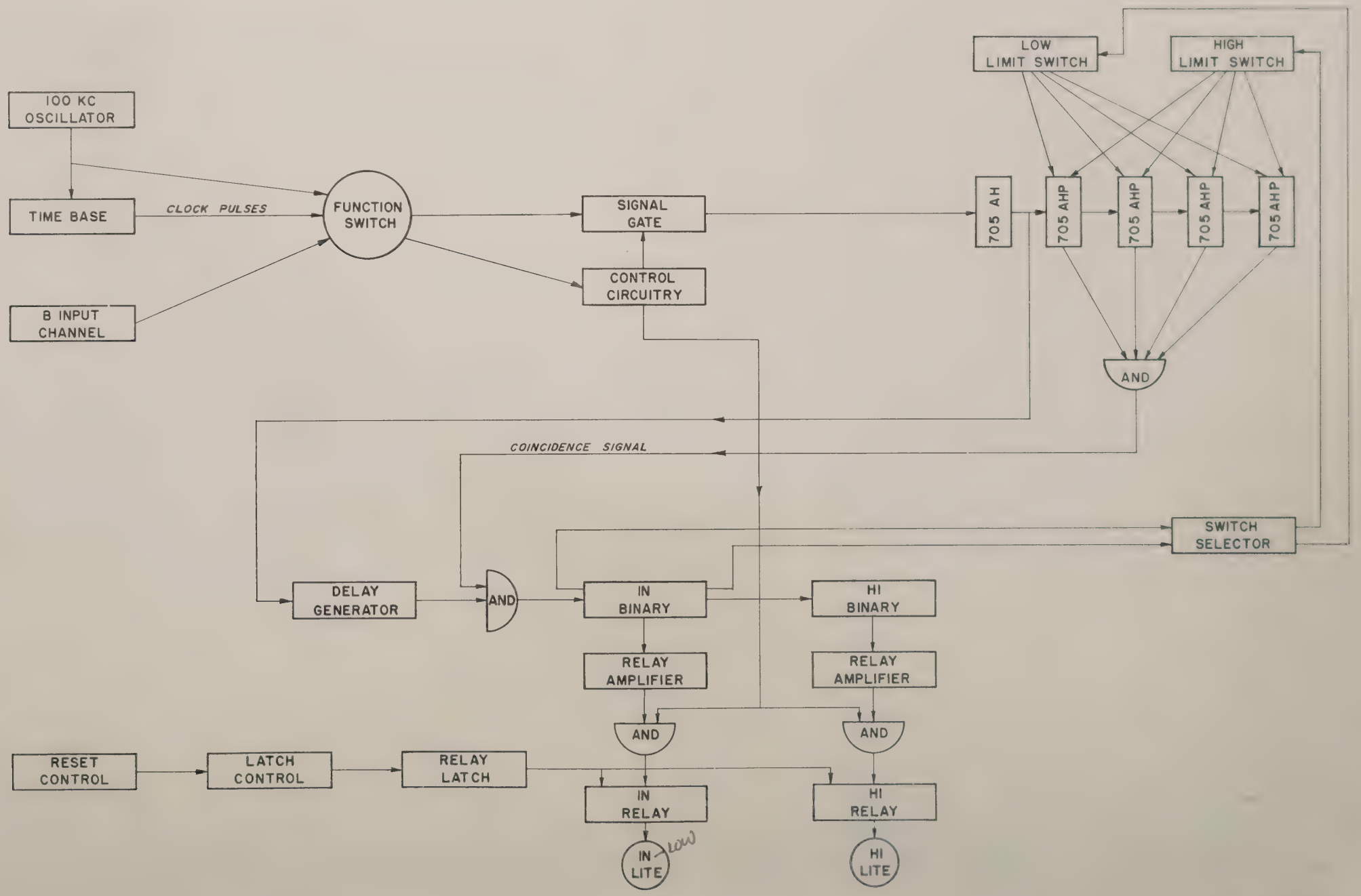
RESISTORS:

WATTAGE 1/2W UNLESS NOTED OTHERWISE.
TOLERANCE 5% UNLESS NOTED OTHERWISE.

CAPACITORS:

CAPACITY IN μμf UNLESS NOTED OTHERWISE.
VOLTAGE RATING

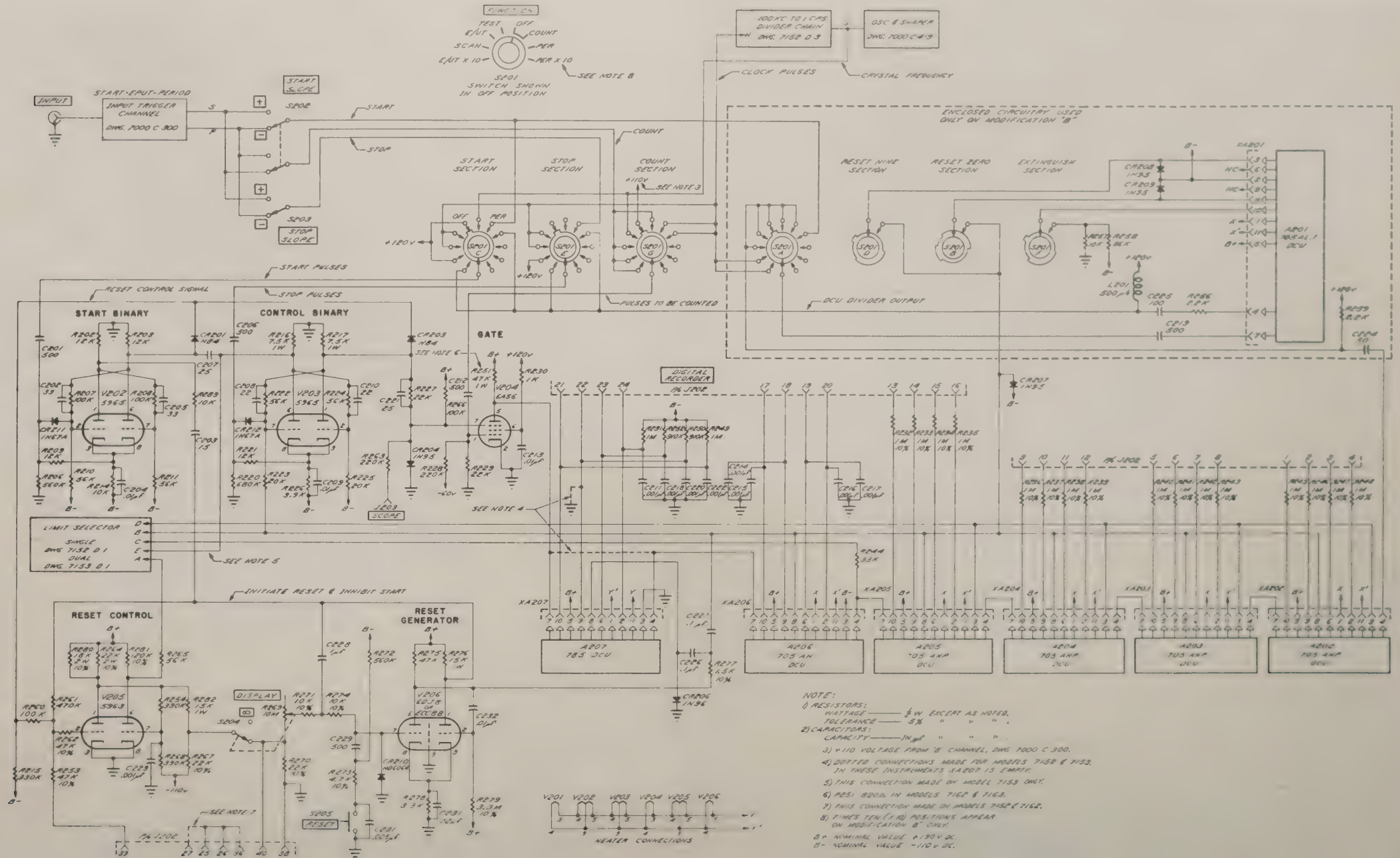
MODEL 7153 LIMIT EPUT LOGIC DIAGRAM



Oct 1959

BECKMAN/BERKELEY DIVISION
DWG. NO. 7153 C 4

GATE, CONTROL & COUNTING CIRCUITS
SCHEMATIC DIAGRAM



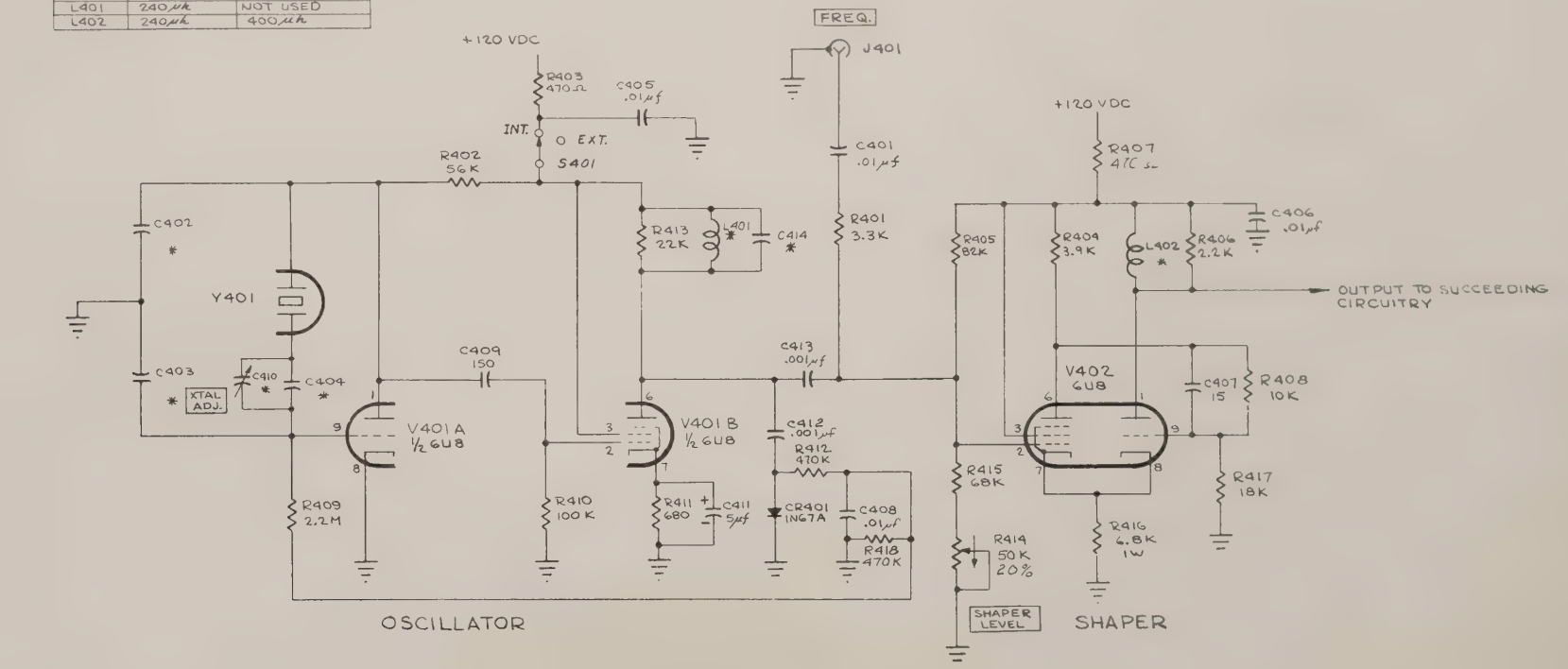
NOTE:
1) RESISTORS:
WATTAGE ——— ½ W EXCEPT AS NOTED.
TOLERANCE ——— 5% " " " .
2) CAPACITORS:
CAPACITY ——— IN μf " " " .
3) +110 VOLTAGE FROM 'B' CHANNEL, DWG 7000 C 300.
4) DOTTED CONNECTIONS MADE FOR MODELS 7158 & 7153. IN THESE INSTRUMENTS XA207 IS EMPTY.
5) THIS CONNECTION MADE ON MODEL 7153 ONLY.
6) R251 820Ω IN MODELS 7162 & 7163.
7) THIS CONNECTION MADE ON MODELS 7152 & 7162.
8) TIMES TEN (X10) POSITIONS APPEAR ON MODIFICATION "B" ONLY.
B+ NOMINAL VALUE +130 V DC.
B- NOMINAL VALUE -110 V DC.

BECKMAN/BERKELEY DIVISION
DWG. NO. 7152 D 2

OSCILLATOR & SHAPER SCHEMATIC DIAGRAM

* COMPONENT VALUES ARE AS LISTED BELOW

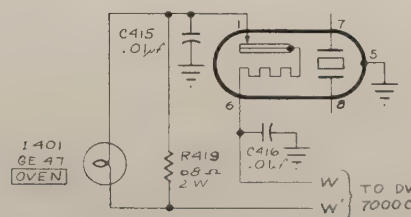
COMP.	WITH 1 MC XTAL	WITH 100 KC XTAL
C402	180 μμf	500 μμf
C403	400 μμf	1200 μμf
C404	68 μμf	39 μμf
C410	2-18 μμf	100 μμf VAR.
C414	100 μμf	NOT USED
L401	240 μh	NOT USED
L402	240 μh	400 μh



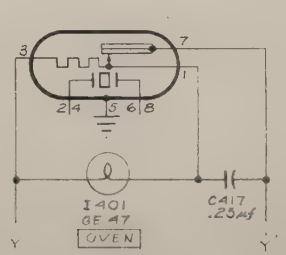
NOTE:
1. RESISTORS:
   WATTAGE - ½W UNLESS OTHERWISE NOTED
   TOLERANCE - 10% " "
2. CAPACITORS:
   CAPACITY - IN μμf UNLESS OTHERWISE NOTED

3 NO OVEN INDICATOR LIGHTS ON MODELS 7151, 7351, 7161 & 7361

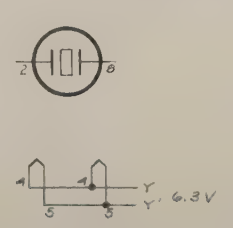
1MC CRYSTAL (Y401) 13-5696



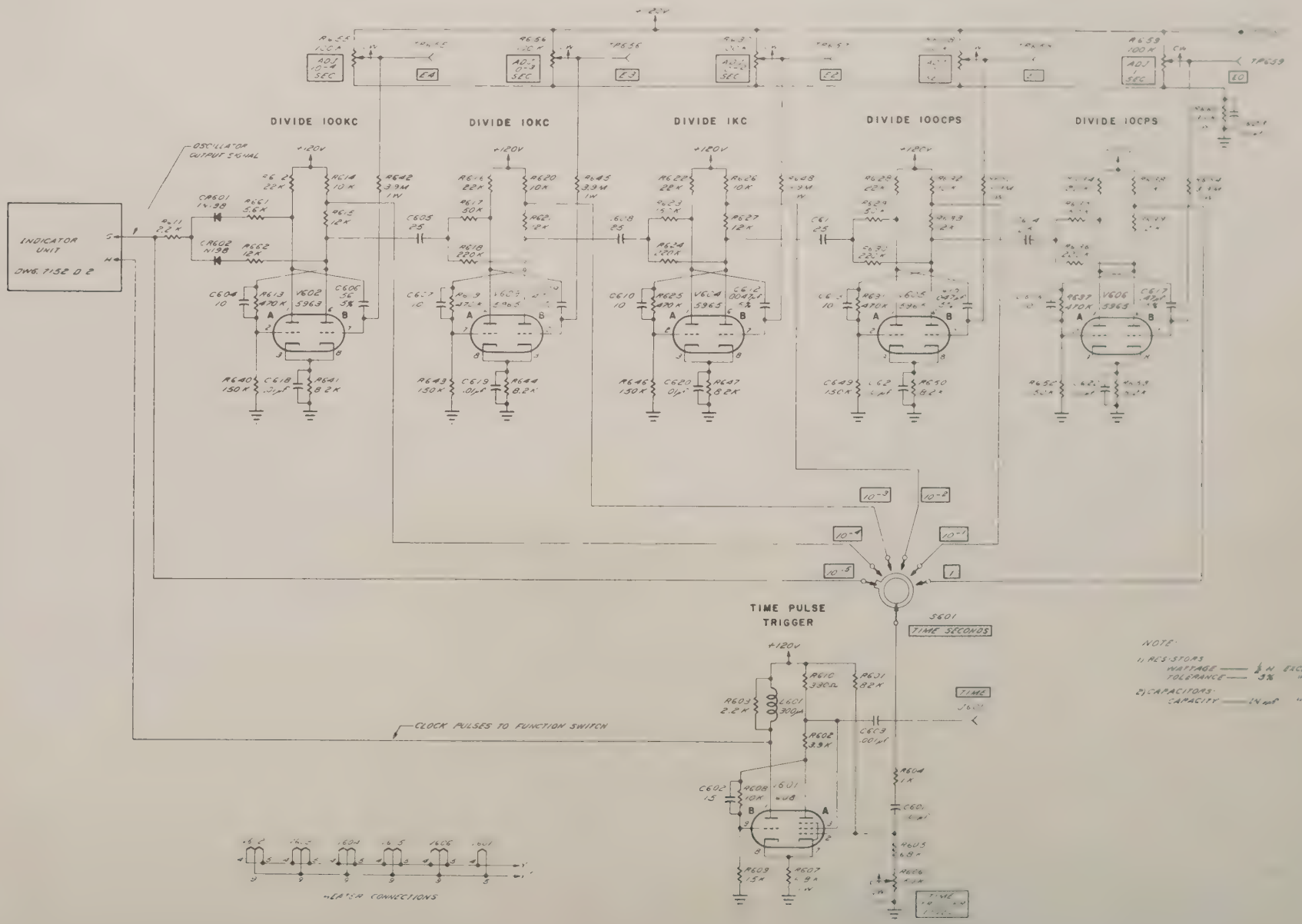
100 KC HEATED CRYSTAL (Y401) 13-6325



100 KC CRYSTAL UNHEATED (Y401) 13-6326

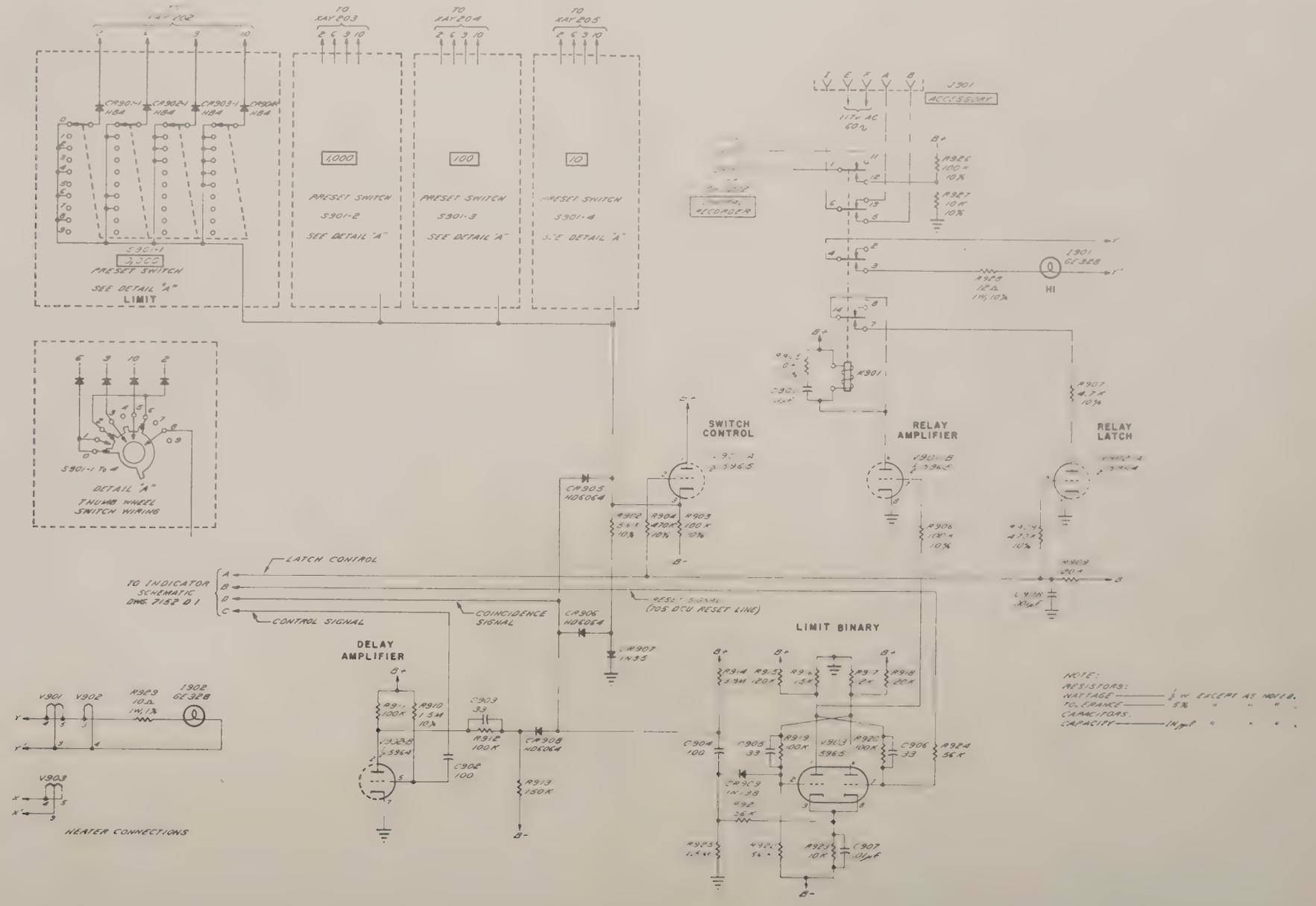


DIVIDER CHAIN, 100 KC TO 1 CPS
SCHEMATIC DIAGRAM



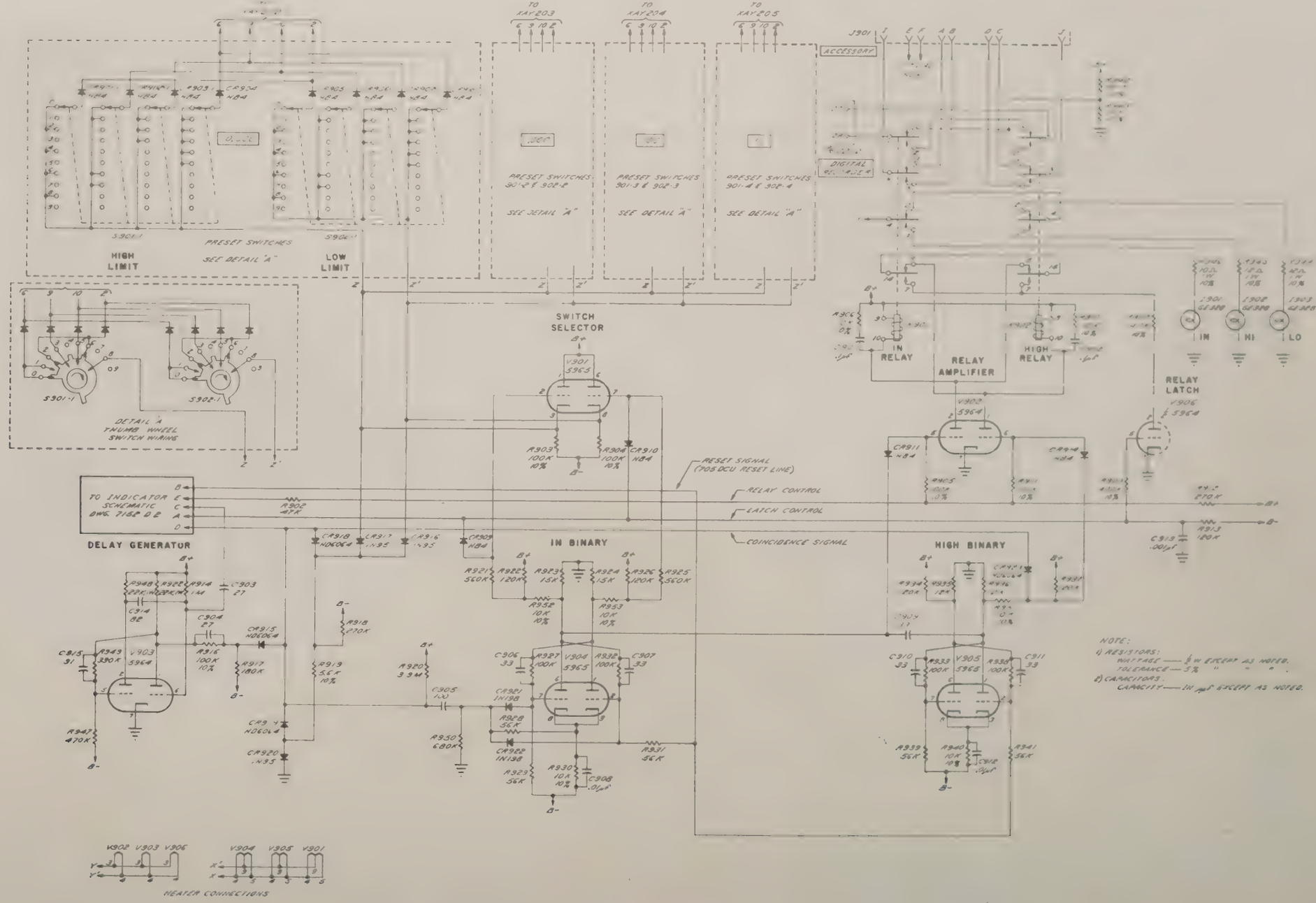
BECKMAN/BERKELEY DIVISION
DWG. NO. 7152 D 3

SINGLE LIMIT SELECTOR CIRCUIT SCHEMATIC DIAGRAM

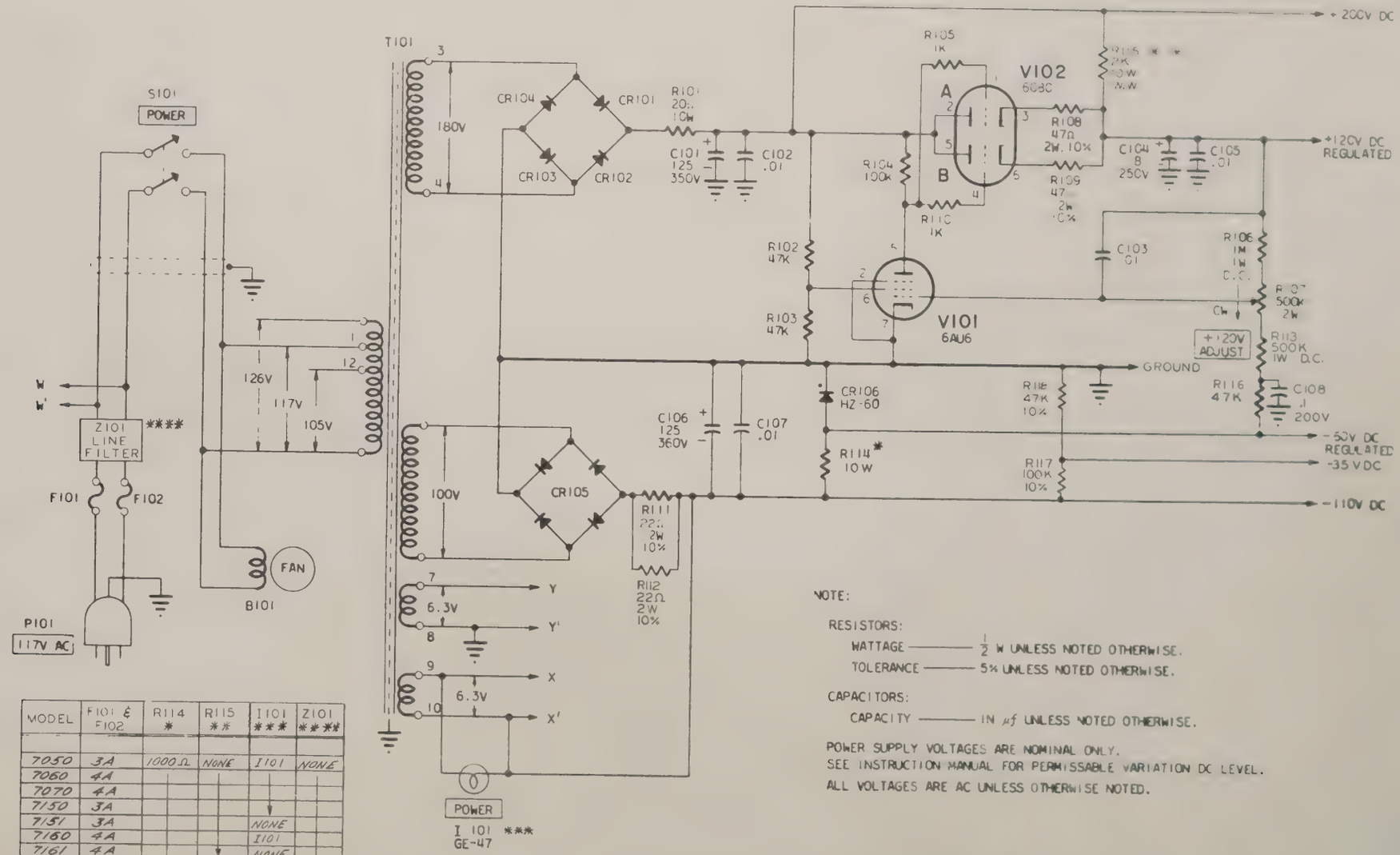


BECKMAN/BERKELEY DIVISION
DWG. NO. 7152 D 1

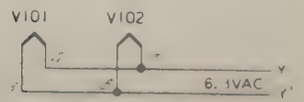
DUAL LIMIT SELECTOR CIRCUIT SCHEMATIC DIAGRAM



POWER SUPPLY SCHEMATIC DIAGRAM



MODEL	F101 & F102	R114 *	R115 **	I101 ***	Z101 ****
7050	3A	1000Ω	NONE	I101	NONE
7060	4A				
7070	4A				
7150	3A				
7151	3A			NONE	
7160	4A			I101	
7161	4A			NONE	
7170	4A		R115	I101	
7250	3A		NONE		
7260	4A				
7270	4A	600Ω	R115		
7350	3A	1000Ω	NONE		
7351	3A			NONE	
7360	4A			I101	
7361	4A			NONE	
7370	4A	600Ω	R115	I101	
5571	4A	700Ω	NONE		Z101



HEATER CONNECTIONS

NOTE:

RESISTORS:
WATTAGE ——— $\frac{1}{2}$ W UNLESS NOTED OTHERWISE.
TOLERANCE ——— 5% UNLESS NOTED OTHERWISE.

CAPACITORS:
CAPACITY ——— IN μf UNLESS NOTED OTHERWISE.

POWER SUPPLY VOLTAGES ARE NOMINAL ONLY.
SEE INSTRUCTION MANUAL FOR PERMISSABLE VARIATION DC LEVEL.
ALL VOLTAGES ARE AC UNLESS OTHERWISE NOTED.

7160	7351	7361	5571
7250	7151	7361	
7260	7050	7170	
7350	7060	7270	
7360	7150	7370	

INSTRUCTION MANUAL

Models 705AH, 705AJ & 705AK
DECIMAL COUNTING UNITS

Lot No.

BERKELEY division
Beckman Instruments, Inc.

Richmond 4, California
18 March 1957

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect.

(b) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(c) The Company shall be released from all obligations under its warranty in the event repairs or modifications are made by persons other than its own service personnel or authorized representatives' personnel unless such repairs by others are made with the written consent of the Company.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

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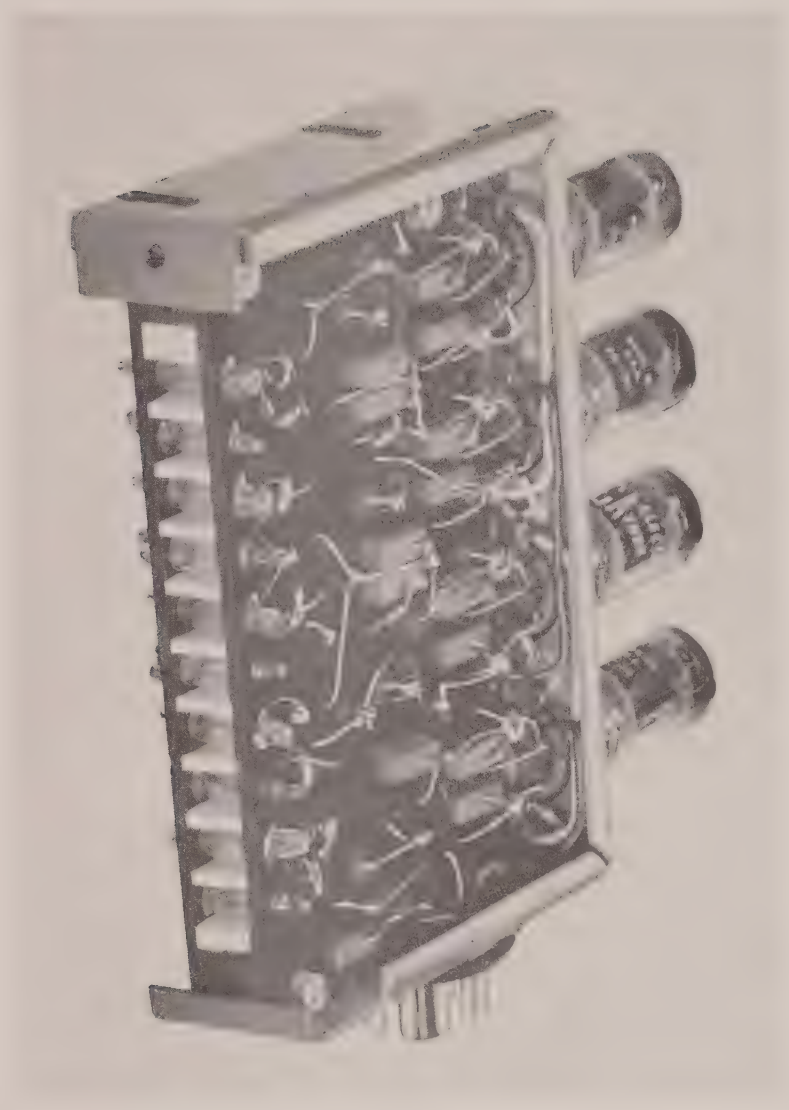
PLEASE NOTE

Some tube types in this unit may not correspond to those shown on the schematic diagram. Type 7316 is equivalent to 5963, and type 7119 is equivalent to 5687.



Model 705AH Decimal Counting Unit with side covers and indicating panel removed.

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INTRODUCTION

These decimal counting units are direct-reading, plug-in electronic counters. The number of input pulses received is indicated by the illumination of one of ten neon lamps placed behind a numbered acetate panel. Each unit counts from zero to nine, the tenth pulse resetting the counter to zero and simultaneously generating an output signal. Any number of these units can be connected in cascade (the output of one unit driving the next) forming a counter whose total count capacity depends only on the number of DCU's. Thus, five units will count to 99,999 resetting to "00,000" on the 100,000th pulse.

Models 705AH and 705AK generate a binary coded decimal readout. This code is in the form of high or low voltages at each of four pins on the DCU plug.

SPECIFICATIONS

Count Indication

Direct reading, decimal presentation

Power Requirements

Heaters: 6.3 v. at 1.2 amps

Plates: 300 v. at 13 ma

Input Requirements

Negative pulses (See "OPERATION")

Output Characteristics

Designed to drive a Model 705A DCU or any modification thereof (i.e., 705AH, 705AK, etc.)

Resolution of Paired Pulses

5 microseconds

Reset

Will reset to either zero or nine depending on polarity of reset pulse applied.

Maximum Counting Rate

100,000 counts per second

Construction

Plug-in unit, 11-pin socket

OPERATION

Power Requirements. The heaters require 6.3 volts ac at 1.2 amperes. The plate circuits may be operated on from 200 to 400 volts, although the design center is 300 volts at 13 ma. Plate voltage may be applied in the form of B + and B - voltages. The d-c level of all output voltages will depend upon the level of the plate supply voltages.

Input Requirements. A negative pulse at least two microseconds wide is required to drive the unit. The optimum pulse amplitude depends on the rise time. With a rise time of 0.5 microseconds (measured between ten and ninety percent values) the pulse amplitude should be between 75 and 135 volts. With a two-microsecond rise time, the amplitude should be between 120 and 165 volts. When operating the plate circuits on 300 volts, optimum performance is obtained with a rise time of one microsecond or less and a pulse amplitude of 100 volts. If the unit is powered by unregulated d-c supplies, the input pulse amplitude should vary in phase with the supply voltage. The input load presented when an input pulse occurs is 15K ohms in series with 100 micromicrofarads.

Output Characteristics. The output is the rectangular waveform shown in Figure 3. As every tenth input pulse triggers the unit from count display "9" to count display "0", a negative transient occurs at pin 4 of the DCU plug. With a plate supply of 300 volts, the potential at pin 4 drops from + 135 to + 55 volts with respect to B-. This transient can be used to drive succeeding decimal counting units or other circuitry. The load impedance connected

between the output terminal and ground must not be less than 300K or 6K in series with 100 micro-microfarads.

Method of Resetting after a Counting Period. A DCU can be reset to a registered count of either zero or nine by the application of a voltage pulse of the proper polarity to the proper pin of the DCU plug. See the table below.

	RESET TO ZERO		RESET TO NINE	
	Pulse Polarity	Applied at Pin No.	Pulse Polarity	Applied at Pin No.
705AH	Neg.	8	Pos.	8
705AJ	Neg.	8	Pos.	8
	Pos.	3	Neg.	3
705AK	Neg.	8	Pos.	8

The reset pin (or pins in the base of Model 705AJ) should be maintained at the B- supply voltage except when a reset pulse occurs. A 50-volt pulse at least 3μseconds wide is adequate. A 100-volt pulse need be only 1.5μseconds wide. There is no maximum pulse width; however the DCU will not begin counting again until the reset pin returns to the B- supply voltage.

Simply disconnecting a reset pin from B- with a switch or relay will have the same effect as applying a positive pulse.

Binary Code Readout. Models 705AH and 705AK generate a modified binary code representing the decimal digit registered. The code appears in the form of a voltage (high or low) at one plate of each of four double-triode binaries. In the table below, "0" represents a plate voltage of approximately +55 volts with respect to B-; "1" represents a plate voltage of about +135 volts with respect to B-. (These are the voltage levels which appear when using a 300-volt plate supply.) Each of the four plates is coupled to a pin of the DCU plug through a 1.2 megohm resistor except in the case of pin 4 on the 705AK DCU. This pin is connected directly to a plate of the fourth binary. To obtain a readout voltage at this pin, it is necessary to add a 1.2M resistor externally.

DECIMAL DIGIT REGISTERED	FOUR - LINE BINARY CODE			
	1st Binary Stage (Pin 2 of DCU plug)	2nd Binary Stage (pin 6 of DCU plug)	3rd Binary Stage (Pin 9 of DCU plug)	4th Binary (Pin 10, 705AH) (Pin 4, 705AK)
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	1	1	0
5	1	1	1	0
6	0	0	1	1
7	1	0	1	1
8	0	1	1	1
9	1	1	1	1

Extinguishing the Indicating Lamps During the Counting Period. On Models 705AJ and 705AK, it is possible to prevent the neon bulbs from lighting by placing approximately -100 volts with respect to B- on pin 10 of the DCU plug. Ordinarily, the user will wish to extinguish the bulb while the DCU is actively counting, and to allow them to light, indicating the registered count at the end of a counting period.

CIRCUIT DESCRIPTION

The Binaries. The decimal counting units contain four "flip-flop" circuits. These circuits are slightly modified versions of the Eccles-Jordan trigger circuit. They are referred to here as binaries.

Figure 1 is a schematic diagram of a typical binary. It consists of two triode voltage amplifiers with the plate of each direct-coupled to the grid of the other. With no input this circuit assumes one of two stable states: V1 conducting steadily and V2 cut

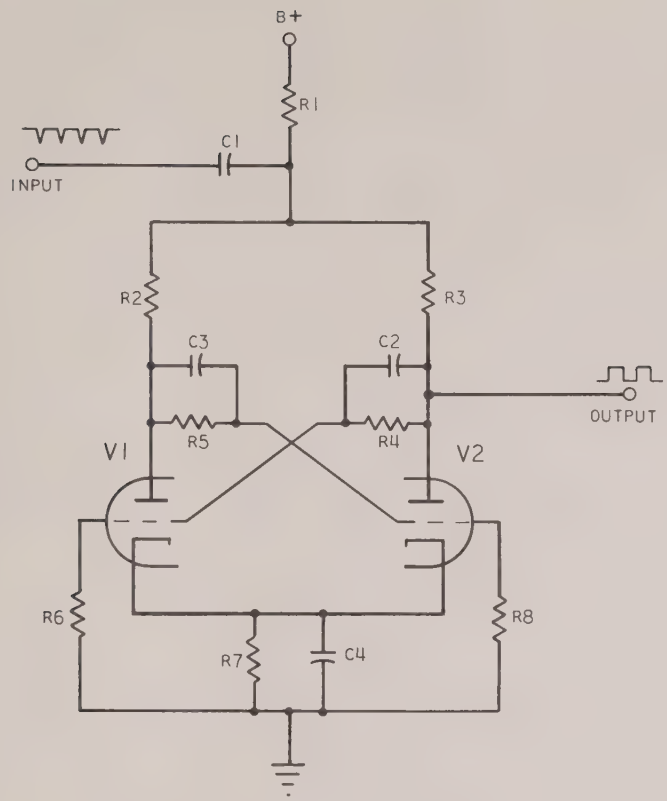


FIGURE 1. A TYPICAL BINARY.

off, or V2 conducting and V1 cut off. Suppose V1 is not conducting. Then, its plate is near the B- voltage. A portion of this voltage, applied to the grid of V2 through the voltage dividing network R5 and R8, raises this grid above cut-off and permits V2 to conduct. While V2 is conducting, the low positive potential at its plate, coupled to the grid of V1 through the dividing network R4 and R6, holds this grid several volts below cut-off. Since small changes in the potential at the grid of V1 will not raise it above cut-off, this state is stable and will persist until disturbed by an appreciable input signal. Notice that, since the circuit is symmetrical, the opposite state is equally stable.

The circuit is triggered from one state to another by negative pulses applied at the input. For example, assume that V2 is conducting and V1 is cut off. If a negative pulse is applied to the input, there is a drop in the plate voltage of V1. This drop in voltage is transmitted through a crossover network (R5, R8, C3 and the grid-to-ground capacitance of V2) and applied to the grid of V2. The plate voltage of V2 then starts to rise, carrying with it the grid of V1. If the input pulse is of sufficient amplitude, V1 begins to conduct. The moment V1 conducts, the drop in voltage at its plate, coupled to the grid of V1, reinforces the negative transient there. This regenerative action proceeds rapidly until V2 is cut off and V1 is conducting at a steady rate. The next adequate input transient causes a reverse action and returns the binary to its original state. Thus, the binary completes a cycle for every two input transients applied, making it a scale-of-two. The output is the drop in voltage at one of the plates as that triode begins to conduct. This output, consisting of one negative transient for every two input transients, is suitable for driving another binary. By connecting binaries in cascade (output of one to input of the next) a counter having a scale of any power of two can be built.

The Scale of Ten. In the Model 705A four binaries are connected in cascade forming a scale-of-16 which is permuted to a scale-of-10 by two positive feedback paths. (See Figures 2 and 3). For the first three negative input pulses, the unit operates like a simple binary counter. At the fourth input pulse, the third binary is triggered for the first time, sending a pulse through the first feedback path which triggers the second binary. Since it requires two input pulses to trigger the second binary, this is equivalent to adding two input pulses; therefore, the state of the unit now

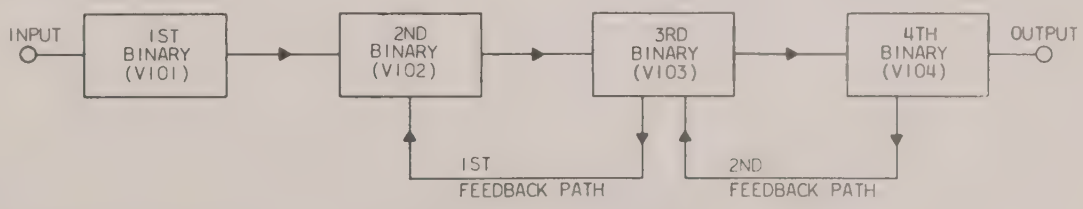


FIGURE 2. BLOCK DIAGRAM.

corresponds to a binary count of six. The sixth input pulse (equivalent to the eight in a simple binary chain) triggers the fourth binary which sends a pulse through the second feedback path, triggering the third binary. This is equivalent to adding four more input pulses so the state of the unit now corresponds to a binary count of 12. For the next four input pulses (7 thru 10) the unit operates again as a simple binary chain, producing an output pulse at the tenth input pulse. Adding the equivalent of six input pulses internally has changed the binary chain from a scale-of-16 to a scale-of-10.

When the third binary is triggered by a feedback pulse, it tends to retrigger the second binary in the same way that it did at the time of input pulse four. This tendency is offset by a simultaneous opposing signal from the fourth binary.

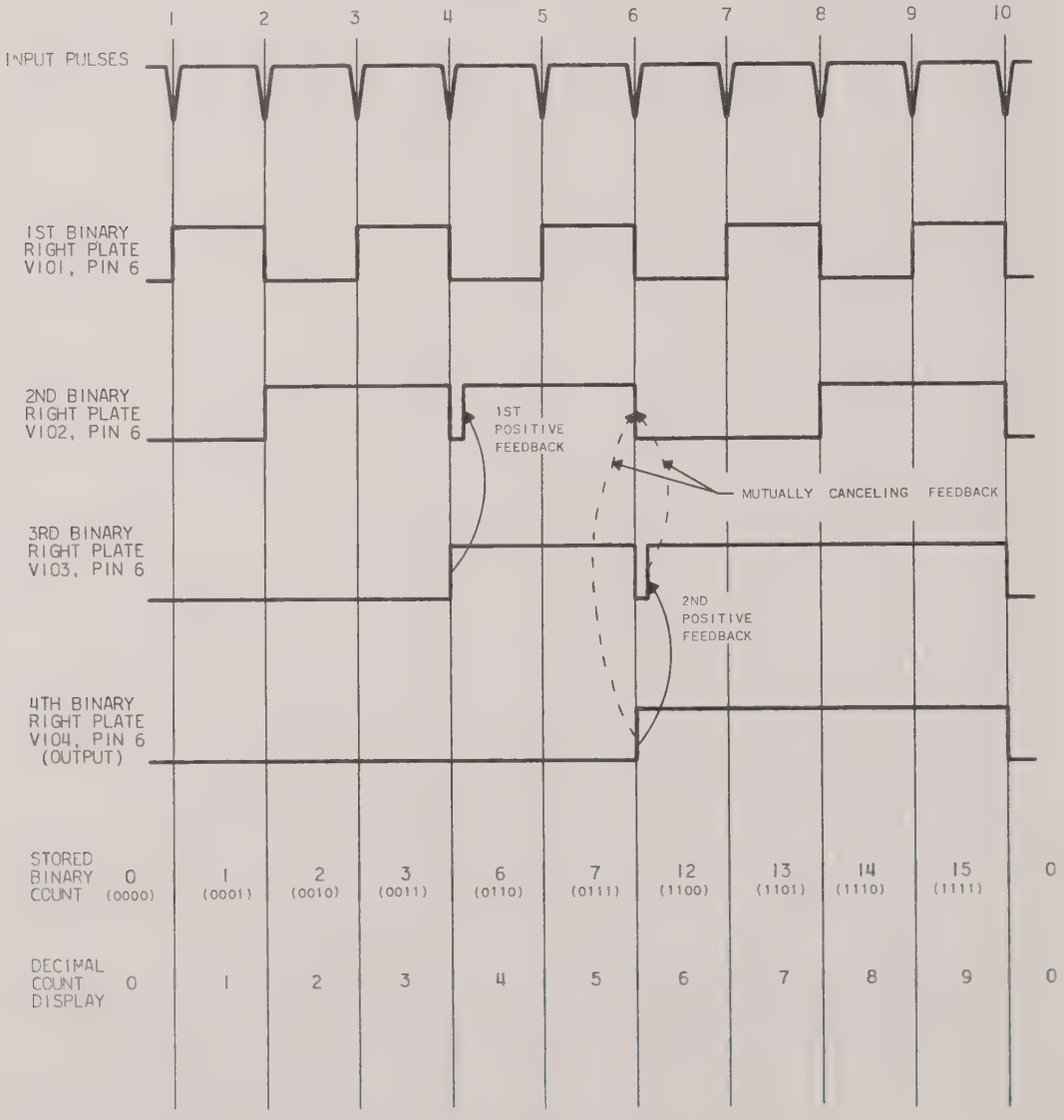


FIGURE 3. IDEALIZED WAVEFORMS. "RIGHT PLATE" REFERS TO THE PLATE APPEARING ON THE RIGHT-HAND SIDE OF THE BINARY AS DRAWN ON THE SCHEMATIC.

TROUBLESHOOTING PROCEDURES

When a decimal counting unit is suspected of counting incorrectly, it should be interchanged with another unit in the instrument or replaced with a spare unit to determine whether the trouble is in the suspected unit or in the associated circuitry. This test should be made very carefully. Because the counting unit is usually the indicating device of an instrument, it is often accused of operating incorrectly when the fault is external to it.

Two methods are recommended for locating a defect in a DCU. The first is to observe the lighting sequence while driving the unit at a slow pulse rate. The second is to study the output waveform of each binary while driving the unit fast enough to create an oscilloscope display. It is impossible to say which method should be used in every case, since marginal failures may occur at high counting speeds and not at lower counting rates, and vice versa. The first method is the only way that a neon lamp failure can be located, and it can be used to locate component and tube failures. For this reason, it is recommended that this method be used first. The table of common troubles lists the probable defects indicated by particular variations from the proper lighting sequence. Binary output waveforms may be compared with the idealized waveforms of Figure 3 and the photographs appearing in Figure 4 & 5.

A table of typical voltages and resistances has been provided to help the serviceman locate a defect within one of the binary stages. Values may deviate considerably from those given without causing trouble. The fact that the unit is designed to operate at plate supply voltages ranging from 200 to 400 volts is a rough indication of permissable tolerances.

TROUBLESHOOTING CHART

NOTE: Reset unit to zero before testing for symptoms

SYMPTOMS	POSSIBLE CAUSES
Unit Fails to Count	(a) Insufficient supply voltage. (b) Input signal of insufficient amplitude (c) Input signal of wrong polarity. (d) First stage inoperative.
Unit Counts Spuriously	(a) Extraneous input signals. (b) Pulses received through power supply. (c) External voltages picked up by output lead.
Units Counts Erratically	(a) Input signal too large or small, incorrect rise time. (b) Supply voltage fluctuating too much.
Unit Fails to Reset	(a) Stray counts from reset switch or associated circuitry. (b) Defective component.

Units counts regularly but neon bulbs light in wrong sequence and the pattern of lighting is repeated consistently after a definite number of input pulses. One or more bulbs may be lit simultaneously during a cycle but the number of states per cycle remains constant.

1.	Units skips every other number	(a) First stage defective. (b) Input circuit supplies double pulses.
2.	Two stable states per cycle.	(a) Second stage defective(Display sequence may be 01 or 45). (b) Loss of drive to second stage (01).
3.	Four stable states per cycle.	(a) Third stage defective (Display sequence may be 0123 or 6789). (b) Loss of drive to third stage (0123).
4.	Six stable states per cycle.	(a) Output excessively loaded (Display sequence may be 012345). (b) Last stage inoperative (Display sequence may be 012345 or $67^{89}_{23}89$*. (c) Loss of drive to fourth stage (Display sequence may be 012345).
5.	Eight stable states per cycle or any failure where two successive numbers are skipped.	(a) Second or third stage failure.
6.	Ten stable states per cycle, but the lighting sequence is incorrect.	(a) When the wrong neon lamp lights, the trouble is usually a defect in the lamp that should have lit, but it may be a defect in the lamp that lit improperly. It's also possible that more than one lamp will light in place of the correct one.
7.	Twelve stable states per cycle.	(a) When lighting sequence is $0123^{01}_{45}456789$* the cause may be a failure of the first feedback or lowered cathode emission in first or second binary. (b) When the lighting sequence is $01234567^{23}_{89}89$ the cause may be failure of the second feedback or low cathode emission in third or fourth binary.

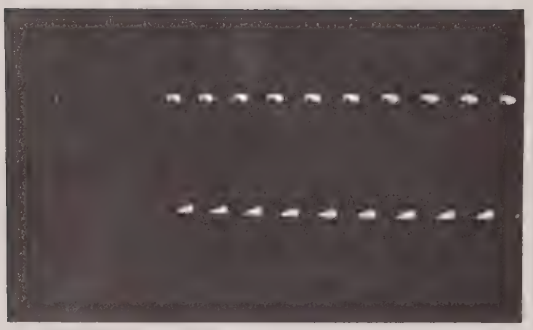
* One digit above another means both lamps are lit.

TABLE OF VOLTAGES & RESISTANCES

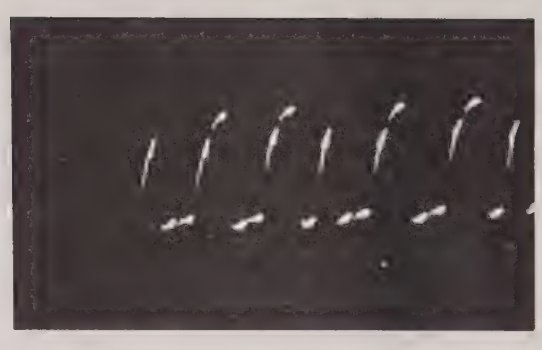
Tube	Pin No.	D-C Voltage with respect to B-.*	Resistance to B minus Terminal**
V101	1	170	105K
	2	17	85K
	3, 8	37	12K
	4, 5, 9	Filaments	
	6	60	105K
	7	37	85K
V102	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K
V103	1	135	100K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	100K
	7	30	83K
V104	1	135	93K
	2	15	83K
	3, 8	30	12K
	4, 5, 9	Filaments	
	6	55	93K
	7	30	83K

* Voltages measured in unit with 300-volt plate supply

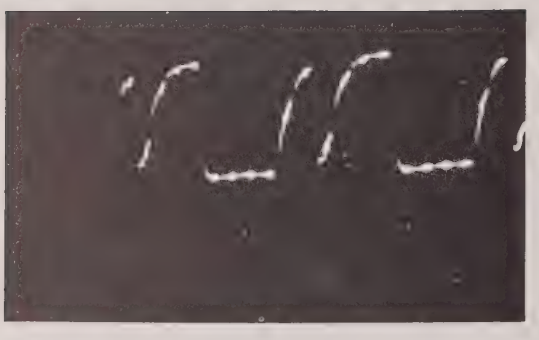
** Before making resistance measurements jumper pins 3 and 8 on the DCU plug.



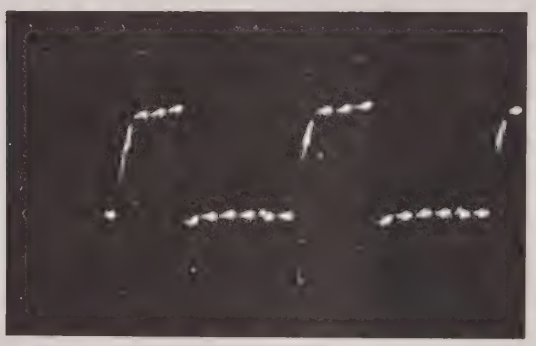
(1) First Binary Output (V101, Pin 6).
Upper voltage level is +168v
Lower voltage level is +55v



(2) Second Binary Output (V102, Pin 6)
Upper voltage level is +140v
Lower voltage level is +55v.

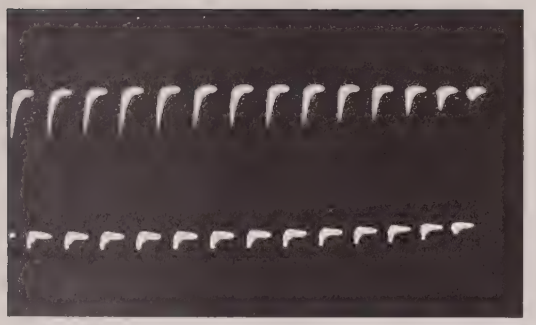


(3) Third Binary Output (V103, Pin 6)
Upper voltage level is +140v.
Lower voltage level is +55v.

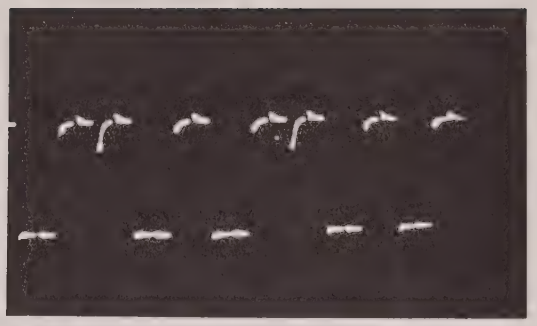


(4) Fourth Binary Output (V104, Pin 6).
Upper voltage level is +140v.
Lower voltage level is +55v.

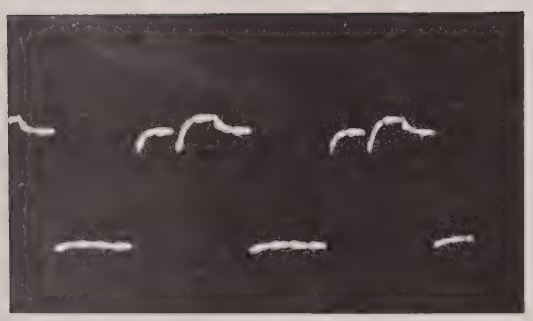
FIGURE 4. BLANKED WAVEFORMS AT INPUT FREQUENCY OF 20KC. ALL VOLTAGE LEVELS ARE MEASURED WITH RESPECT TO B MINUS.



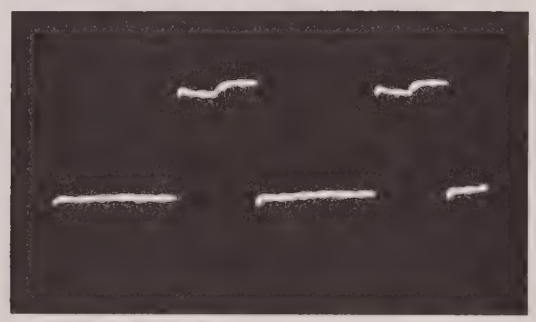
(1) First Binary Output (V101, Pin 6).
Upper Voltage level is +168V
Lower voltage level is +55v



(2) Second Binary Output (V102, Pin 6)
Upper voltage level is +140v
Lower voltage level is +55v.



(3) Third Binary Output (V103, Pin 6)
Upper voltage level is +140v.
Lower voltage level is +55v



(4) Fourth Binary Output (V104, Pin 6).
Upper voltage level is +140v.
Lower voltage level is +55v.

FIGURE 5. BLANKED WAVEFORMS AT INPUT FREQUENCY OF 100KC. ALL VOLTAGE LEVELS ARE MEASURED WITH RESPECT TO B MINUS.

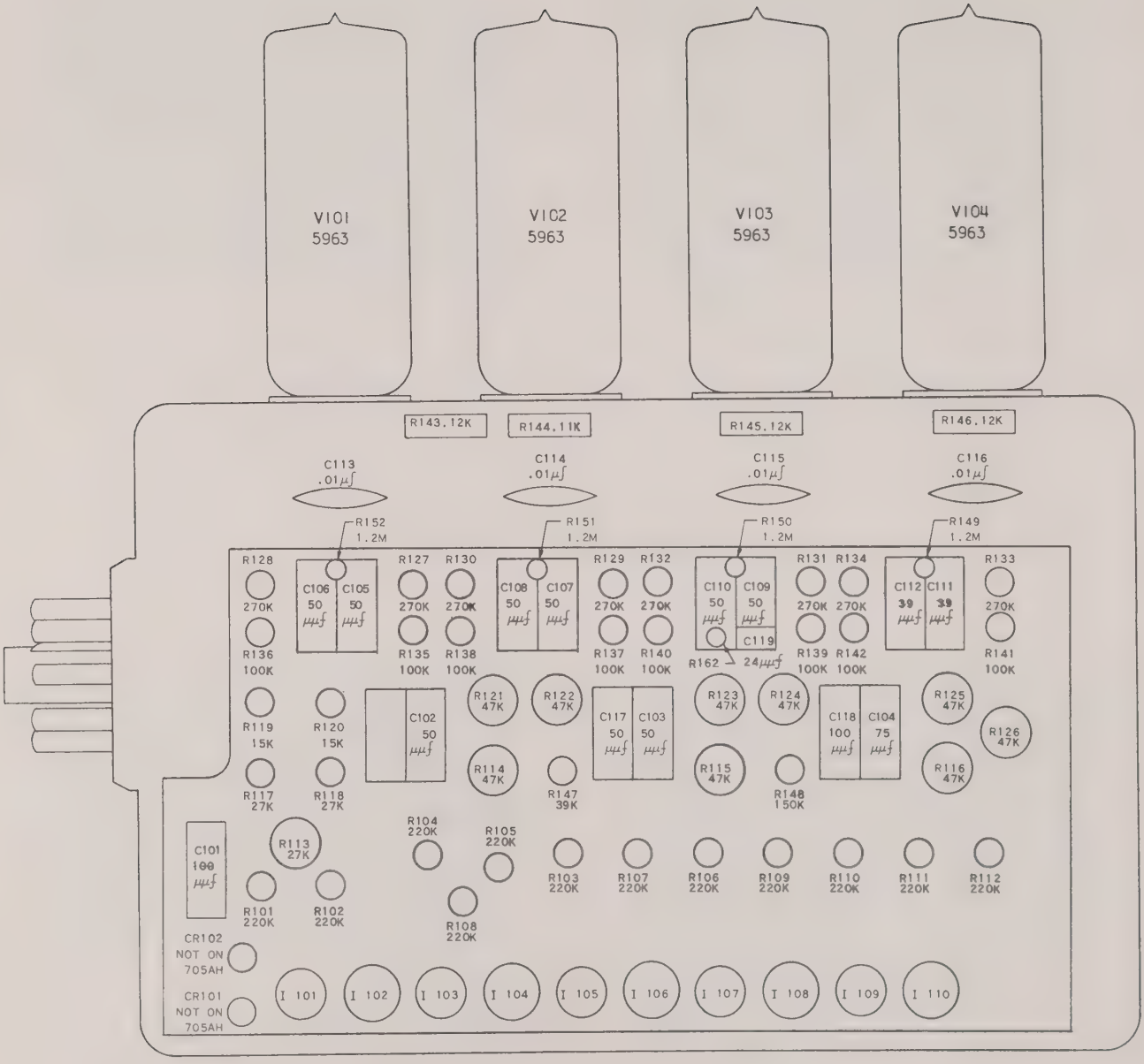
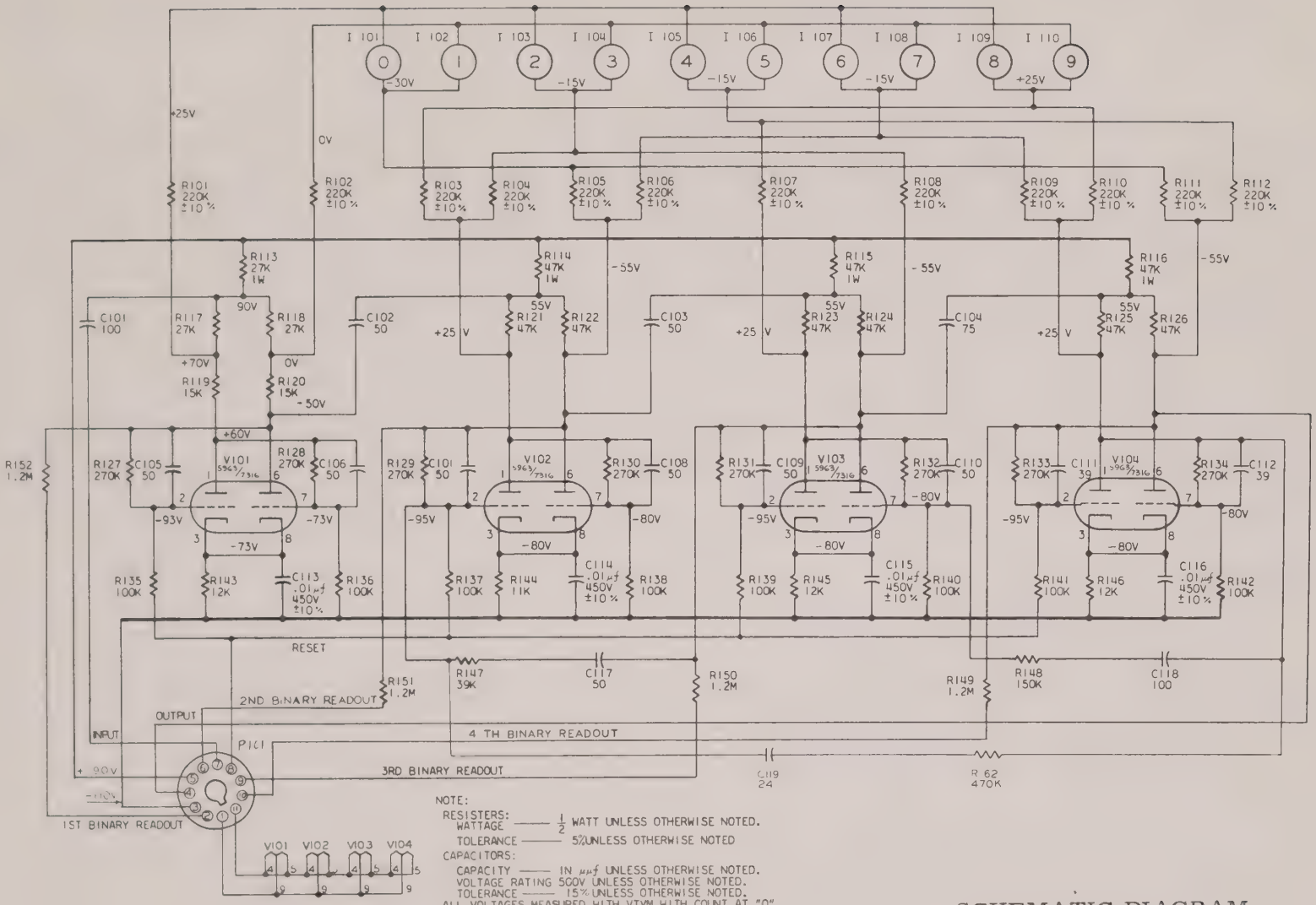
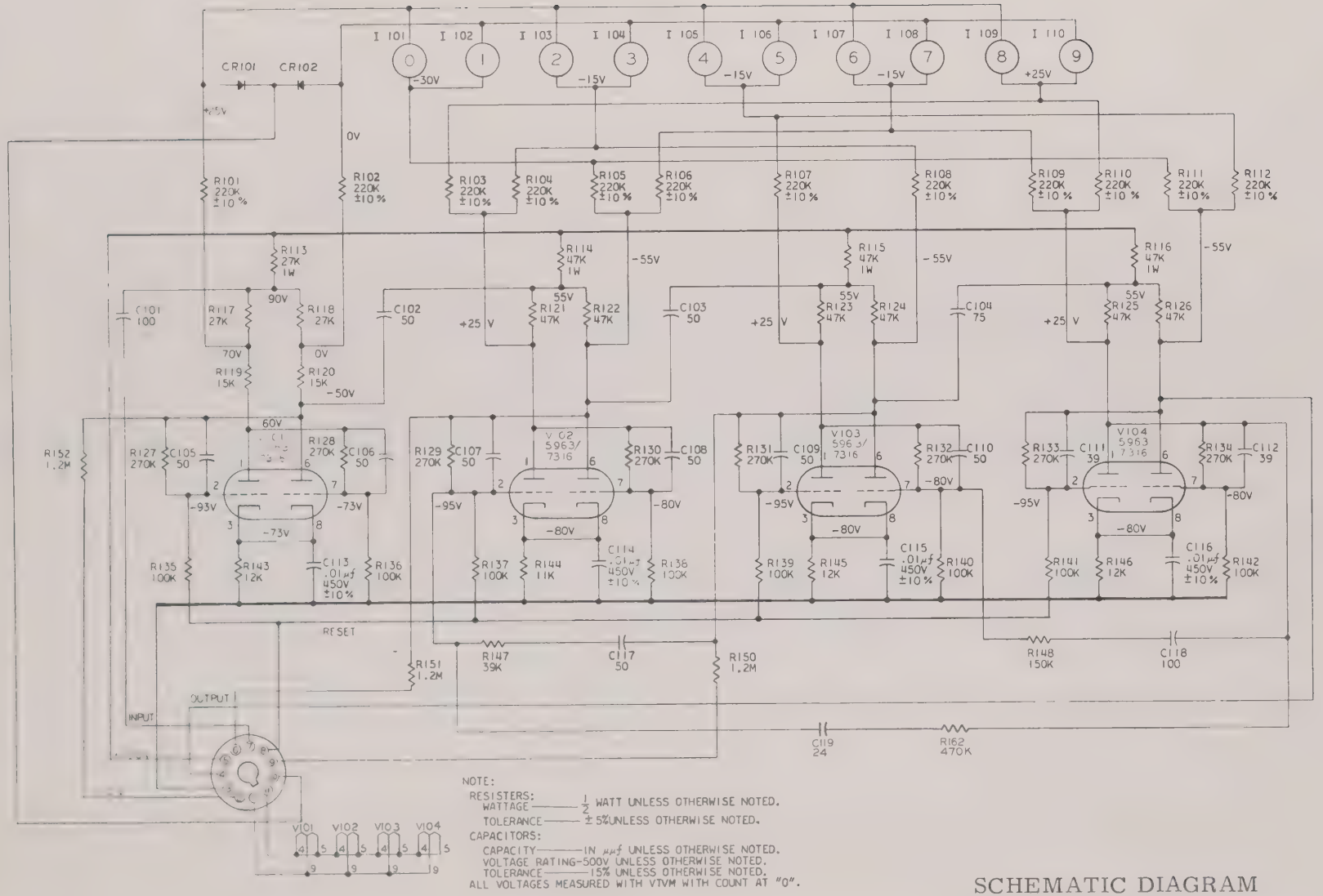


FIGURE 6. PARTS LOCATION



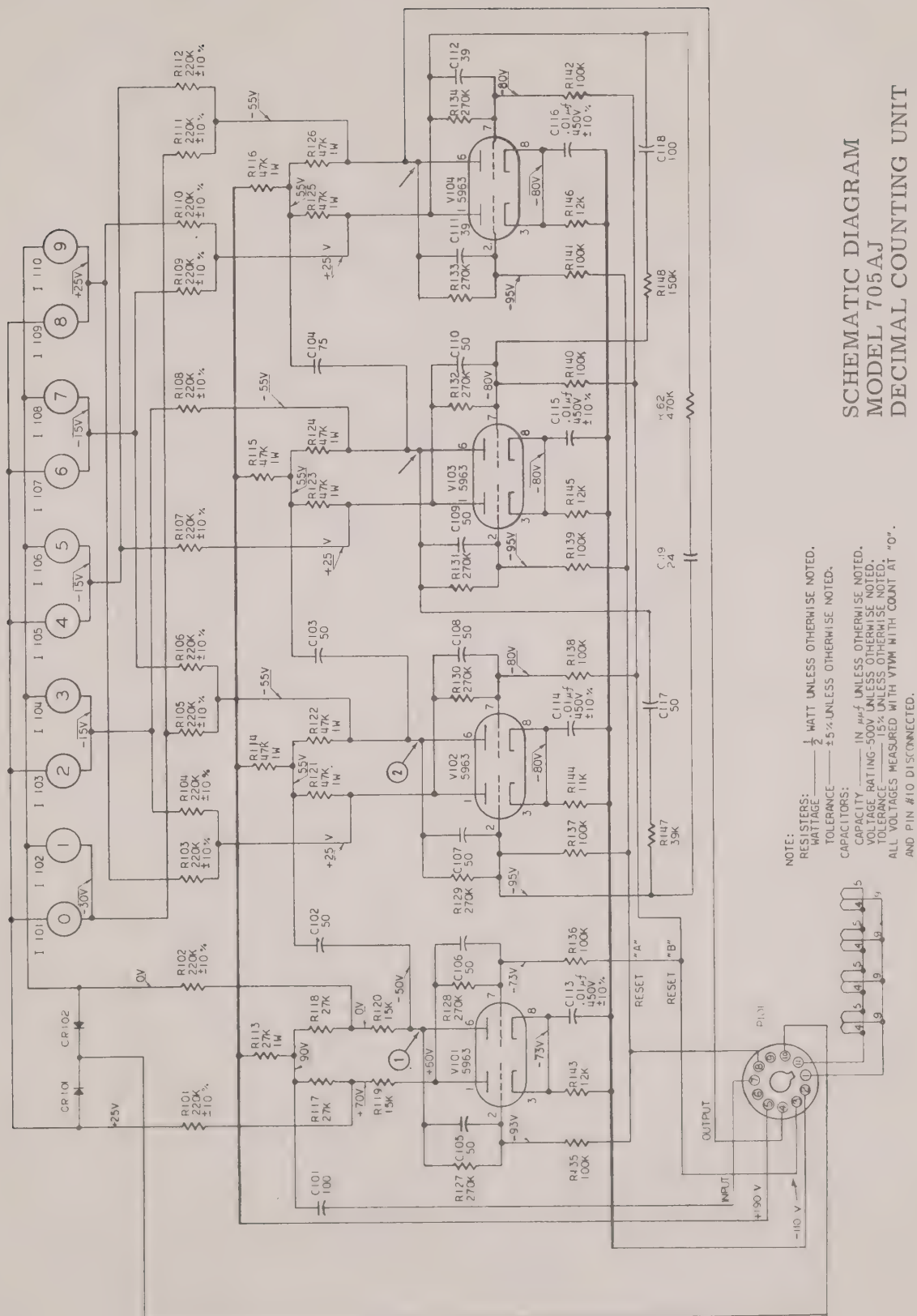
NOTE:
RESISTERS:
WATTAGE —— $\frac{1}{2}$ WATT UNLESS OTHERWISE NOTED.
TOLERANCE —— 5% UNLESS OTHERWISE NOTED
CAPACITORS:
CAPACITY —— IN μμf UNLESS OTHERWISE NOTED.
VOLTAGE RATING 500V UNLESS OTHERWISE NOTED.
TOLERANCE —— 15% UNLESS OTHERWISE NOTED.
ALL VOLTAGES MEASURED WITH VTVM WITH COUNT AT "0".

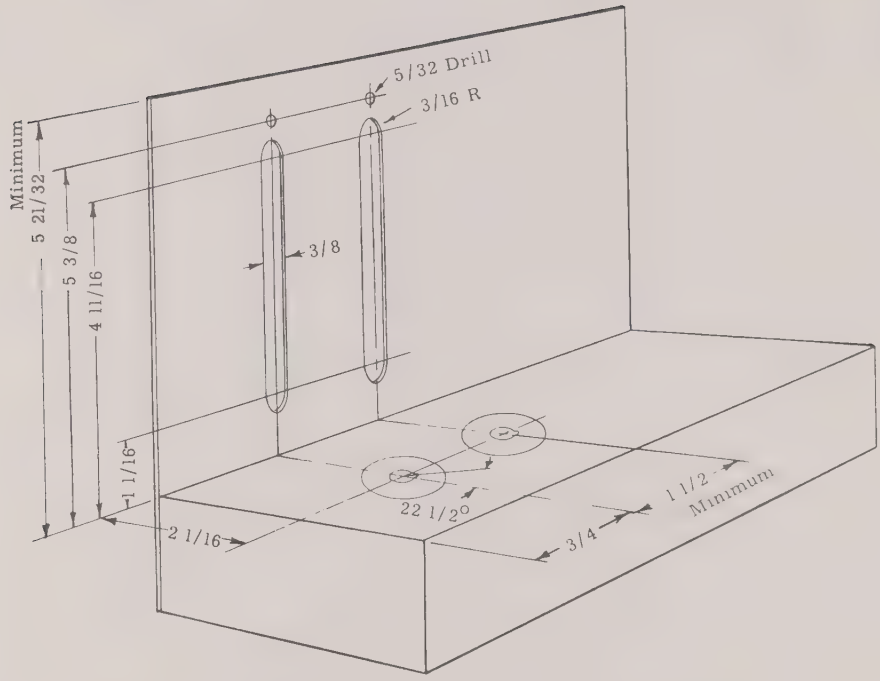
SCHEMATIC DIAGRAM
MODEL 705AH
DECIMAL COUNTING UNIT



NOTE:
RESISTERS:
WATTAGE——— $\frac{1}{2}$ WATT UNLESS OTHERWISE NOTED.
TOLERANCE——— ± 5% UNLESS OTHERWISE NOTED.
CAPACITORS:
CAPACITY——— IN μμf UNLESS OTHERWISE NOTED.
VOLTAGE RATING-500V UNLESS OTHERWISE NOTED.
TOLERANCE——— 15% UNLESS OTHERWISE NOTED.
ALL VOLTAGES MEASURED WITH VTVM WITH COUNT AT "0".

SCHEMATIC DIAGRAM
MODEL 705AK
DECIMAL COUNTING UNIT


SCHEMATIC DIAGRAM
MODEL 705AJ
DECIMAL COUNTING UNIT
NOTE:
RESISTORS: WATTAGE ½ WATT UNLESS OTHERWISE NOTED.
TOLERANCE ±5% UNLESS OTHERWISE NOTED.
CAPACITORS:
CAPACITY IN μμf UNLESS OTHERWISE NOTED.
VOLTAGE RATING-500V UNLESS OTHERWISE NOTED.
TOLERANCE 15% UNLESS OTHERWISE NOTED.
ALL VOLTAGES MEASURED WITH VTVM WITH COUNT AT "0".
AND PIN #10 DISCONNECTED.
OUTPUT
INPUT
+190 V
-110 V
RESET "A"
RESET "B"



NOTE: Dimensions are based on the use of an Amphenol "MIP" 8 or 11-pin socket mounted above the chassis.

The drawing shows chassis dimensions for mounting two Model 705A DCU's side by side. All modifications of the Model 705A (705AH, 705AF, etc.) have precisely the same dimensions as the standard 705A.

Mounting Dimensions, Model 705A and All Modifications Thereof

INSTRUCTION MANUAL
MODEL 705AHP
DECIMAL COUNTING UNIT

Beckman/ Berkeley Division
Richmond 3, California

November 1959

DECIMAL COUNTING UNIT
MODEL 705AHP

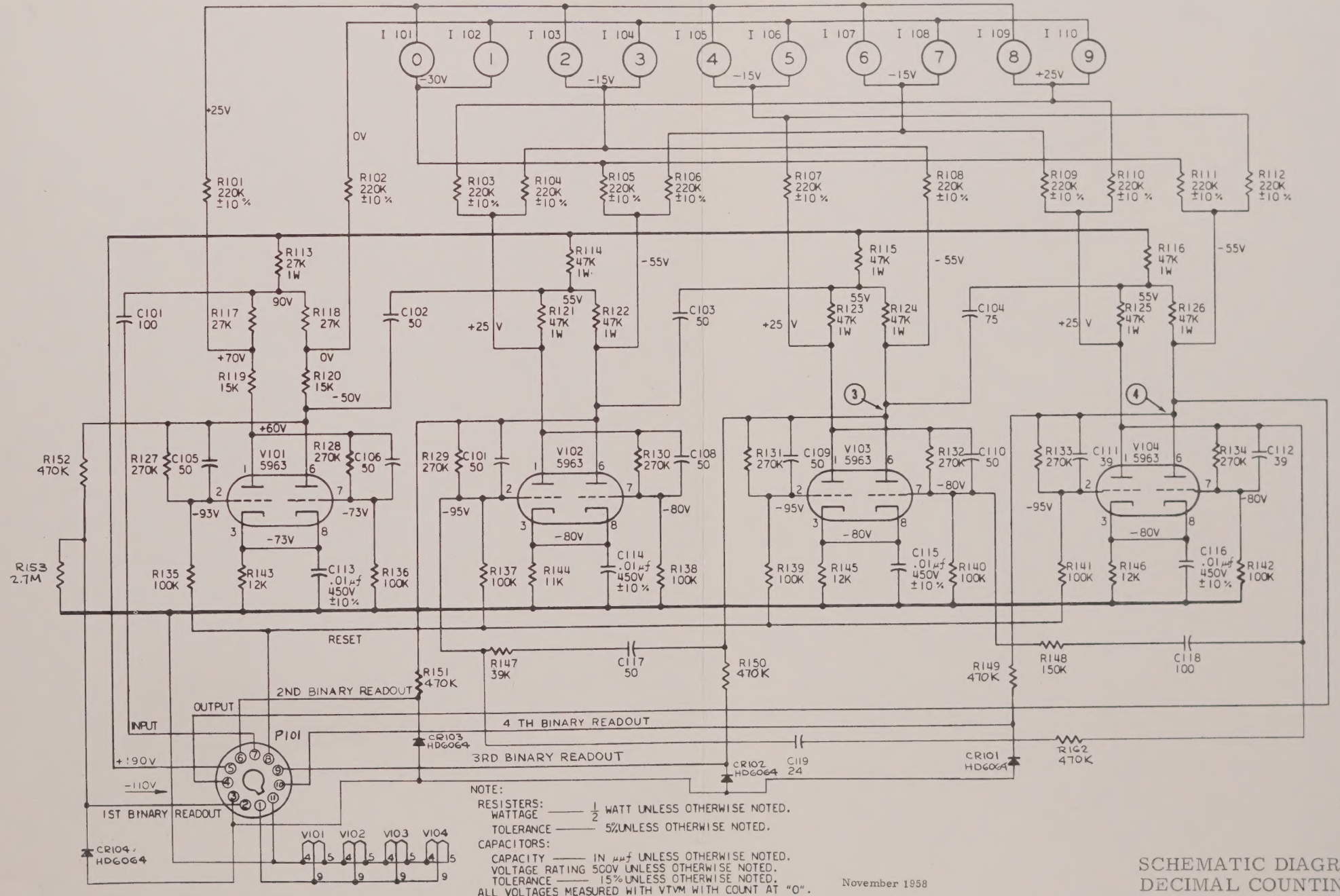
The Model 705AHP is a modified version of the standard Model 705AH DCU (see dwg. 705 C 266). With the following exceptions, this unit is identical to the Model 705AH:

(1) Four diodes, CR101 through CR104, have been added. Each of these is wired from a corresponding binary readout line to the coincidence line at pin 3 of the DCU plug.

(2) The 1.2 M resistors in the binary code readout lines (R152, R151, R150, R149) have been replaced by 470K resistors.

(3) The first binary readout line (pin 2 of the DCU plug) is shunted to ground through a 2.7M resistor.

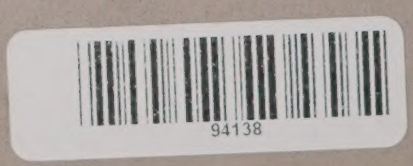
(4) The -110 volt bus is connected to pin 11 of the DCU plug instead of pin 3.



NOTE:
RESISTERS:
WATTAGE —— $\frac{1}{2}$ WATT UNLESS OTHERWISE NOTED.
TOLERANCE —— 5% UNLESS OTHERWISE NOTED.
CAPACITORS:
CAPACITY —— IN μμf UNLESS OTHERWISE NOTED.
VOLTAGE RATING 500V UNLESS OTHERWISE NOTED.
TOLERANCE —— 15% UNLESS OTHERWISE NOTED.
ALL VOLTAGES MEASURED WITH VTVM WITH COUNT AT "0".

November 1958

SCHEMATIC DIAGRAM
DECIMAL COUNTING UNIT
MODEL 705AHP
DWG. NO. 705 C 266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